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SPARKS TO HEAD FINANCIAL AID COUNCIL

Dr. Frank Hugh Sparks has been elected president of the Council for Financial Aid to Education, Inc., succeeding Dr. Norman P. Auburn, who returns to the presidency of the University of Akron in March. Also announced recently were the elections of David H. Henry, president of the University of Illinois, Gwilym A. Price, chairman of the Westinghouse Electric Company, and Robert W. Woodruff, former Chairman of the Coca Cola Company, as members of the Council board.

The Council is a non profit organization founded in 1953 by businessmen to help corporations and private donors develop educational aid programs. It conducts periodic surveys of corporation giving practices and of college needs, making the information available to donors and prospective donors.

DO YOU KNOW . . . .

► . . . . That this year's Annual Meeting is the second one at Berkeley? The first was in 1940. Be prepared for a visit to a busy campus, and remember that it is on the side of the Berkeley Hills. Practice walking up and down hills and steps. A short visit to confer with the local committee left some impressions . . . a compact campus—many blooming flowers and shrubs—lots of unusual trees—steep walks and drives—Strawberry Creek—Grizzly Peak as the background—no geometrical pattern of streets and buildings—beautiful views of the bay—much new construction, some of it causing changes in plans—local committee well advanced with its plans—even if you just pick up now and go, things will be ready for all of you, men, women, and children.

► . . . . That the minutes of the April meeting of the Executive Board are briefed on page 934? Reading them will keep you abreast of Society business.

► . . . . That three ASEE groups presented testimony to House and Senate committees studying federal aid to education? President F. C. Lindvall, Vice President R. A. Morgen, and G. E. Arnold, Chairman of EJC's Engineering Manpower Commission, were invited to testify in person before the Senate Committee and submitted similar written testimony to the House Committee. Their comments were based on the CDEF report printed in the May issue of the JOURNAL. K. L. Holderman, K. O. Werwath and E. H. Rietzke were invited to appear before the Senate Committee on behalf of technical institute education. The major point in their testimony was that technical institute education is higher education and that any federal legislation drafted to serve higher education should be written so as not to exclude work done at two-year institutions and work of technical institute type. The Co-operative Engineering Education Division submitted a letter to the Senate Committee requesting that legislation adequately and fairly provide for students wishing to enroll in accredited five-year cooperative programs. ECAC also sent a letter to deans of engineering at member institutions which would serve as a basis for letters to congressmen, and urged the deans to write such letters.

► . . . . That the "development of the meaning, opportunity, responsibility of American citizenship, development of respect for the dignity of man, and the sense of belonging are the primary purposes of education for all youth"? At least that is what the National Association of Secondary School Principals said in testimony presented to the Senate Committee on Labor and Public Welfare.

► . . . . That those interested in heat transfer and fluid mechanics will want to remain in Berkeley through Saturday June 21? The 1958 Heat Transfer and Fluid Mechanics Institute sponsored by six California universities and six engineering societies is to be held at Berkeley on June 19, 20, and 21. Aeros, M.E.s, and Ch.E.s will be interested. The papers will be devoted to problems in fluid mechanics which require consideration of thermal phenomena, chemical reactions, and electro-magnetic fields. For additional information write to Professor A. K. Oppenheim, Mechanical Engineering Department, University of California, Berkeley, California.

► . . . . That "Retention and Withdrawal of College Students" is a 1958 Bulletin of the U. S. Office of Education? First-time students enrolling in institutions of higher education in the United States in the fall of 1950 are considered. Some extracts from the summary follow.

Of the students who graduate in the upper half of their classes from the secondary schools in the United States, about one-half go to college on a full-time basis and about three-fourths of them eventually receive a baccalaureate degree. No more than 60 per cent of all students who enter degree-granting institutions receive degrees. About 40 per cent of the freshman class remain at the institution of first enrollment to graduate four years later. An additional 20 per cent will either graduate later from the first institution or from another institution in four or more years.

Students were almost unanimous, regardless of their ability level or the type of institution in which they were enrolled, in expressing a low opinion of the performance of the counseling, guidance, and orientation functions in higher education. It might be inferred that students withdraw because of inability or unwillingness to endure dissatisfactions, rather than because of dissatisfactions. The major cause of student transfers was summed up in the expression, "I was generally dissatisfied." A change in curricular interest is the second most important reason for transfer. For men, lack of interest in studies ranked second in importance as a reason for leaving college and personal financial difficulties ranked third. General factors indicated that many students enrolled in institutions in which the prospects of completing their programs of study were very poor.

Copies of the report may be obtained for sixty-five cents from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

► . . . . That in the first 950 new members for this year, 289 different schools were represented? 107 were from nonschools, 110 from two-year program schools, 17 from Canada, 17 from Puerto Rico, 3 from Hawaii, 2 from Mexico, 2 from Iran, one from Brazil, and one from India. The top twelve schools are:

University of Illinois	36
University of Arizona	29
Missouri School of Mines	25
Purdue University	22
University of Washington	22
Penn. State University	18
Newark College of Engr.	17
Illinois Institute of Tech.	10
Kansas State University	10
Michigan College of Min. & Tech.	10
University of Dayton	10
W. Virginia University	10

615 new members come from the active member institutions in the continental United States, an average of about four per school; similar figures for the affiliate members are 51, an average of somewhat more than one. This indicates that the YETS have been working, but an average of only four new members per school isn't very good. The potential for expansion is still great. Let's each resolve to get a new member next year!

► . . . . That the 152 active members of ASEE grant 89 per cent of all B.S. degrees in Engineering? That 128 grant 99 per cent of the M.S. degrees and that 61 grant 100 per cent of the Ph.D. degrees?

► . . . . That during the past few months there has been a veritable flood of papers for inclusion in the Annual Meeting Program? This situation has not existed in the past, and

the interest of members and nonmembers in making contributions is greatly appreciated. However, papers thus submitted seldom can be included for presentation at the Annual Meeting.

Most Divisions and Committees start their planning one year in advance. This is necessary in order to have information in the hands of the Secretary's office by the first of Februrary so that all aspects can be correlated, printed in the Preliminary Program, and distributed to the membership during the first part of April.

To some this seems a ridiculously long drawn-out schedule, but the total time of about 10 weeks may be broken down as follows: 3 to 4 weeks in the ASEE office to assemble 40 to 50 individual programs into a unified whole, straightening out uncertainties, filling the gaps, preparing clean copy, submitting copy to each program chairman, and finally, mailing to the printer; 2 to 3 weeks for preparation of galley proof, checking, conferring with laggards, incorporating last minute changes, and returning to the printer; about 2 weeks for receipt of page proof, making more additions and changes, prodding laggards some more, and mailing final copy to the printer; about 2 weeks for printing and mailing. Only after page proof has gone to the printer do decisions become arbitrary and replies say, "we are sorry, but this was asked for two months ago." Oh yes, and then come more corrections, a few more additions, and room assignments, and the printing of the Final Program just in time for the meeting. This is the mechanism of the development of the program for an Annual Meeting . . . and all the time the usual office routine continues.

► . . . . That a broad survey of dentistry in the United States is being made by the American Council on Education? The $400,000 project will concentrate on dental education, research, practice, and health, and will take two years to complete. Most of the money is coming from the Kellogg Foundation and the American Dental Association. This is further evidence of the need for a study of the engineering profession.

► . . . . That a bibliography on "Liberal Education in American Engineering" is available? The Institute for Higher Education at Teachers College, Columbia University, has been making studies of the role of liberal education in various professional curricula. In addition to engineering, bibliographies have been prepared for law, medicine, dentistry, nursing, pharmacy, and agriculture. These bibliographies are available on request by writing to Dr. E. J. McGrath, Institute for Higher Education, Teachers College, Columbia University, New York City.

► . . . . That another year is about to end for ASEE? It has been an active and productive year, one in which there have been real accomplishments and real gains. To all who have helped so much in so many ways, many thanks! The Collins family looks forward to the California Sunshine, the meetings with old friends and the making of new ones at the Annual Meeting, and then a month in California—the first real vacation in three years.

W. Leighton Collins
Secretary

BEVIS COMMITTEE SEEKS COOPERATION ON HIGH SCHOOL SCIENCE—MATHEMATICS

The following letter from the office of the Chairman, The President's Committee on Scientists and Engineers, Washington, D. C., was addressed to ASEE President, Dr. Lindvall, on December 30, 1957.

Dear Dr. Lindvall:

At the first meeting of the President's Committee on Scientists and Engineers, it was determined that an action program should be undertaken to improve mathematics and science teaching at the elementary and secondary school levels and to interest more young people with aptitude for mathematics and science to take courses in this field. Such a program has been developed and is being carried out under the direction of a Task Force headed by Mr. John S. Coleman, of the National Academy of Sciences. This Task Force is composed of representatives of the organizations listed on the enclosed sheet.

One of the major action steps recommended by the Task Force is the organization of local citizens' committees, composed of representatives of school people, scientists and engineers, industry and labor, and civic groups.

I am asking each member of the President's Committee to publicize the program through the appropriate channels of his organization. I would appreciae it very much if you would arrange to get this information to your membership through your organization's newsletter or other channels.

I am enclosing a brief statement of the proposed program for the use of your information staff. We will be glad to assist with the preparation of a release if you wish.

The staff of the Committee has visited some twenty community and state organizations, reviewed their programs and made a selection of local activities which seem to be most fruitful. This information has been summarized, and along with other pertinent material, assembled in a kit including a "How-To-Do-It" booklet for the use of communities where local programs are less advanced.

The effectiveness of the President's Committee rests very largely on the active support and participation of the organizations represented on it. As you know, the President, in acknowledging on November 29, 1957, the receipt of our second interim report, said: "It is my hope that the organizations whose leaders comprise the Committee, as well as others concerned with these questions, will now use the competent guidance provided by the report and plan and undertake such action as may be appropriate to their aims." You will recall that the report contained a detailed description of this program.

Sincerely,

HOWARD L. BEVIS
Chairman

LOCAL ACTION FOR THE IMPROVEMENT OF MATHEMATICS AND SCIENCE TEACHING

At its first meeting, the President's Committee on Scientists and Engineers discussed the fact that more young people must become interested in mathematics and science courses at the elementary and secondary school levels and that all possible assistance should be given to those who teach mathematics and science. To this end the Committee organized a Task Force composed of representatives of schools, universities and colleges, employers, professional technical societies, and national professional organizations.

The Task Force examined the problem thoroughly and prepared a pamphlet entitled "Improving Science and Mathematics Education" which indicates in summary form how the many sectors of our society can help. In issuing the pamphlet the Task Force also recommended to the President's Committee that it should assume the responsibility for stimulating the formation of committees at local, state and regional levels for this purpose. In making this recommendation the Task Force pointed out that action of necessity must be taken at the school board and state level.

During the spring and summer of 1957 members of the staff of the President's Committee visited and examined the programs of some two dozen localities and states. It was found that successful local action programs generally depended upon the cooperation of community leaders who represented about the same sectors of the community as the task force—namely school and university people, employers, professional societies of teachers, scientists and engineers and civic groups. It was also found that no uniform pattern for the program was developing at the local level. Rather, and this was considered desirable, each local committee developed a program tailored to the needs of its own community.

These programs vary from attempts to raise teachers' salaries and improve the qualifications of teachers by additional training to the sponsorship of local science clubs and science fairs. They include: arrangements with employers to lend engineers and scientists to act as substitute teachers releasing teachers for training meetings or with the help of the teacher present special topics and demonstrations to classes and assemblies; employer loans or gifts of equipment and materials for laboratories or special demonstrations; after-hours training of gifted students by scientists and engineers; field trips for students and teachers to see the most advanced equipment and methodology; scholarships by civic groups, local organizations of employers for gifted students to attend college, and for teachers to attend summer institutes or to take a full year training at a recognized college or university; summer jobs for students and teachers in the field of their interest; the showing of films to students or PTA members, either free or for nominal fees; extra financial support of mathematics and science activities in and out of school; arrangements between schools and colleges and universities permitting gifted children to take courses in high school which may be acceptable for college credit; prizes for outstanding teachers or pupils, sometimes in the form of financial awards.

Some local committees also work with school people on curricula, books, film libraries, closed-circuit TV presentations, minimum-qualification requirements for teachers, and preemployment training of teachers. In some communities these committees assist in planning school construction, with emphasis on science classrooms

and laboratories; budget preparation; public relations with the community, and relations between schools, local colleges, and universities. Obviously no one committee tries to carry on all these functions, but fits its program to local needs.

The Local Action Task Force has held a series of meetings. It has agreed on a statement of its objectives, reviewed and completed a kit of materials to assist in the organization and operation of local committees, and agreed on action steps that need to be taken by the constituent members of the President's Committee. One of these action steps is to stimulate the formation of citizens committees composed of representatives of school people, professional organizations of scientists and engineers, employers, labor, civic groups, and others who might be of assistance in bringing about approved programs for mathematics and science at the elementary and secondary school levels.

The Task Force is now engaged in arranging contacts with a selected number of communities throughout the country. In each case an attempt is being made to build upon and work with those local organizations which are already in action.

A meeting of top industrialists is planned for this winter and spring. The purpose of the meeting will be to interest as many of the industrial leaders as possible in supporting local programs through their branch plants and organizations. At the request of the task force, the chairman of the President's Committee has written to a selected list of presidents of national organizations to solicit their aid. A highly successful regional conference has already been held at Lake Arrowhead, California. Two other regional conferences are being negotiated now. The goal is to cover every major sector of the country through the device of regional meetings so as to stimulate activity locally.

Local Action Task Force

1. Dr. Allen Abrams
   First American State Bank Bldg.
   Wausau, Wisconsin
2. Mr. Robert H. Carleton
   Exec. Secy., National Science Teachers Association
   1201 16th St., N.W.
   Washington 6, D. C.
3. Mr. John S. Coleman (Task Force Chairman)
   Exec. Secretary
   Physical Sciences Division
   National Academy of Sciences
   2101 Constitution Ave., N.W.
   Washington 25, D. C.
4. Mr. Watson Davis, Director
   Science Services
   1719 N St., N.W.
   Washington 6, D. C.
5. Dr. Paul E. Elicker
   Exec. Secretary
   National Association of Secondary School Principals
   1201 16th St., N.W.
   Washington, D. C.
6. Dr. C. H. Maxwell
   Assistant Director Washington Office
   American Medical Association
   1523 L St., N.W.
   Washington, D. C.
7. Dr. John R. Mayor, Director
   Science Teaching Improvement Program
   American Assn. for the Advancement of Science
   1515 Massachusetts Ave., N.W.
   Washington 5, D. C.

8. Dr. John R. Miles
Manager, Education Department
Chamber of Commerce of the U. S.
1615 H St., N.W.
Washington, D. C.

9. Mr. Henry Toy, Jr., President
National Citizens Council for Better Schools
9 E. 40th St.
New York 16, New York

10. Mr. Edward M. Tuttle
Exec. Secy. Emeritus
National School Boards Assn., Inc.
450 E. Ohio St.
Chicago 11, Illinois

11. Mr. Arthur W. Motley
Asst. Director for the Employment Service
Room 5309
U. S. Department of Labor
14th & Constitution Ave., N.W.
Washington 25, D. C.

12. Dr. Glen R. Shepherd
Medical Council on Education and Hospitals
535 N. Dearborn St.
Chicago 10, Ill.

13. Dr. Bradford R. Stanerson
Assistant Secretary
American Chemical Society
1155 16th St., N.W.
Washington, D. C.

14. Mr. Glenn Warneking
National Science Teachers Assn.
1201 16th St., N.W.
Washington 6, D. C.

15. Dr. R. M. Whaley
Exec. Director Advisory Board on Education
National Academy of Sciences
National Research Council
2101 Constitution Ave., N.W.
Washington 25, D. C.

Editorial Note: For this program at community levels, the Local Action Task Force of the President's Committee on Scientists and Engineers looks toward members of ASEE to seed nucleus groups in each locality. These groups should weld together and advance the strong common interests of business people, industry, scientists, engineers, and educators for joint improvement in finding and properly educating the youthful talents our nation can so well use.

Local action kits on community cooperation methods have been prepared and are available for the chairman of the Task Force, Mr. John S. Coleman, at the address given below. These kits contain eight pamphlets on problems and methods, a booklet of case studies in united local action, and a local action bibliography. Industry support will also be sought directly through conferences at regional and national levels.

Write: Mr. John S. Coleman, Task Force Chairman
National Academy of Sciences
2101 Constitution Avenue, N.W.
Washington 25, D. C.

NEW CONCEPTS IN EDUCATION

From the President's Committee on Education Beyond the High School

PAUL REINERT

President, St. Louis University

College-Industry Conference of Relations With Industry Division, University of Michigan, January 30–31, 1958.

President Eisenhower's Committee on Education Beyond the High School was not directed, nor as a group of 36 busy citizens would it have been able, to write a learned treatise on the fundamental philosophy of education which we thought most appropriate for America today. But underlying the practical observations and recommendations in our report are at least three basic concepts of far-reaching implication. These concepts can rightly be called "new", not because they are unheard of in educational history, but because for many Americans the understanding and acceptance of these concepts would be a "new" experience, one which hitherto has played little or no part in the formation of their conscious values.

Respect for Learning

We Americans have unlimited respect for many types of physical and technical skill. Witness our adulation of the "practical" scientist; still more our wild enthusiasm for athletes, movie and TV stars, and quiz experts. In these and many other types of achievement, respect for learning is measured in direct proportion to its usefulness in the pursuit of entertainment, industrial, commercial, or military purposes. This is why our respect for learning rises immediately when we are faced with a crisis in one of these practical aspects of life, as is the case at the present time.

In bold contrast to this appreciation of learning as a utilitarian value is a truer, more enduring concept: the ageless respect for learning as that magnificent accomplishment which is ordered to and consummated in human wisdom. This reverence for learning is founded on the conviction that the development of a human being to a mature level, the fundamental establishment of human personality, is achieved primarily through the acquisition of knowledge and truth. If we look for what is precious and unique in man, we find it in those activities which constitute his conscious life. Undoubtedly such physical realities as the activity and development of man's body are essential elements of his life, but all these have meaning for him only insofar as they undergird, make possible, or are dependent on his conscious life, the process of reaching reality through knowledge and love. Hence, the main humanistic, philosophical, and theological traditions of the West have seen the highest and noblest level of man's life in man's ability to know and love, the activity by which he most completely develops and realizes his potential.

Our Committee is insistent that the widespread respect for learning, for man's pursuit of knowledge for its own intrinsic value, is the most fundamental of all concepts which must be introduced or re-introduced into American society. Instead of suddenly raising our voices against anti-intellectualism because it has endangered our

position with the Russians, we must return to the public recognition of *"ars gratia artis,"* the rightfully permanent place of the pursuit of wisdom in any civilization which hopes to avoid decay. Not all our citizens can or should be scholars, but all are obliged to help in creating and protecting an environment in which learning for its own sake will flourish.

Respect for the Teaching Profession

Books and speeches abound in which we are told that the teacher is the professional guardian of our precious heritage, of the accumulated learning of the past; by his unending pursuit of knowledge through research, the teacher is responsible for the unearthing of new truth, for the knowledge requisite to grapple with new problems; and in the classroom, laboratory, library, and "bull session", the teacher is the professional transmitter of this learning, old and new, to the young men and women who will be tomorrow's America.

Yet, in spite of this exalted lip-service, the President's Committee states categorically that the present disgraceful status of this high vocation is the most crucial single problem confronting education today. The typical college teacher is not able to play his indispensable role and discharge his magnificient duties for the very good reason that he is unable to dedicate himself wholeheartedly to his task. Typically, he lacks the resources and equipment necessary for effective teaching and research in the laboratories and libraries where he works. Still more stultifying, in his own life and that of his family he lacks a well-rounded sense of the respect, the support, the security, and the appreciation which should be accorded him by his institution and by at least the vast majority of our citizens. We believe that the roots of this problem lie deeply imbedded in our present social structure, so deeply imbedded that it will take the combined effort of most of our citizens to eradicate this cancerous growth.

The primary cause of this disease is the deteriorated, distorted attitude toward the teaching profession commonly found among parents, youngsters, and the public generally. It would take far too much time to trace the genesis of this deterioration. Suffice it to say that springing from this fundamental social attitude are several secondary causes, each contributing substantially to the total deleterious effect. Among these secondary but very important causes is, for example, the disillusionment created by parents in the home, by the printed and spoken word in our entertainment media, and by teachers themselves in the minds of young men and women who have the ability and who sense an urge to enter the teaching profession. Another powerful secondary cause, of course, is the lack of esteem for teaching dramatically evidenced by the inadequate salaries so common in this profession.

The President's Committee was presented with appalling evidence of the speed with which this deterioration is taking place at the college teaching level. Four years ago (1952–1953) only 31.4 per cent of the men and women newly entering the college teaching field possessed the Ph.D., the educational background normally required for such positions. During the past year (1956–57) this percentage had already dropped to 23.5 per cent, and this in spite of the fact that the production of Ph.D.'s is four times greater than it was ten years ago. Obviously, those best qualified for college teaching are turning their backs and heading for jobs in industry and business. Three of every four new Ph.D.'s in chemistry who take new

jobs upon graduation go outside educational environs. Three of every five new Ph.D.'s in physics and other physical sciences take the same path (cf. *Teacher Supply and Demand in Colleges and Universities, Research Division, N.E.A., 1957*).

When a man is dying, the physician may recommend drastic remedies. With the same sense of desperate urgency, our Committee stated:

"that boards of trustees, legislatures, and all others responsible for academic budgets (must) give the absolute highest priority for raising the salaries of college and university teachers as substantially as may be necessary to reach and then to maintain levels which, together with other advantages, will provide the teaching profession with an equitable share of our best talent and abolish the faculties' hidden subsidy to education. In the light of both necessity and equity the Committee suggests that the goal be set at no less than double the present average level on the overall national basis within five to ten years, although it recognizes that there are, and will be, substantial differences by region and institution." (*Second Report to the President, the President's Committee on Education Beyond the High School, pp. 35–36.*)

In its insistence on the crying need for improved salaries to enhance the prestige of the teacher, the Committee is equally insistent that such increases should not perpetuate or even accentuate the serious imbalances in remuneration among the various fields of teaching. Differences in salary levels are inevitable among regions and institutions. But within institutions sharp differentials in favor of those in teaching fields most eagerly sought after by industry and government is in our opinion another contributing factor to the general deterioration of the profession because of the dissatisfaction and bad morale this imbalance nurtures between professors in the physical sciences and those in the humanities and social sciences.

The 1956 study "Salaries and Earnings of Engineering Teachers" prepared for the Committee on Development of Engineering Faculties of the American Society for Engineering Education indicates that the average engineering teacher earns a salary of $6,634 per year, but brings his total annual earnings to $8,862 by consulting and other engineering work. While we would agree that these are not adequate salaries to attract, increase, and retain the supply of competent teachers needed for engineering colleges, nevertheless, we contend that even this present differential between the average college teacher's salary of $5,400 as compared with $6,634 is just another serious obstacle to the quality and stability of our total college and university faculties.

This is why I am opposed (here I am speaking for myself, not the Committee) to some of the new legislative proposals which presumably will come before this session of Congress in response to the national concern about our technological deficiencies. One proposal would provide $150,000,000 in federal funds to raise the pay of grade and high school science and mathematics teachers. Every high school principal and superintendent I have consulted is vigorously opposed to this program as one which would not only be extremely difficult to administer but would inevitably be an added source of the bitterness and disillusionment already too common within our teaching ranks.

What is desperately needed, then, and at the earliest possible moment, is the acceptance on the part of millions of Americans for the lost concept of the unparalleled importance of the teaching profession to society. This concept will guarantee the public understanding, the esteem, the financial

support, and all the other elements necessary to elevate all levels and divisions of our teaching profession to that lofty calling which alone will be capable of providing the quality education America needs today.

Respect for the Learner's Right to Differentiated Educational Opportunities

Today almost every thinking American stands in awe at the almost unbelievable results of basic and applied research in our technological fairyland. Almost equally impressive are creative achievements in other fields such as sculpture, painting, and music. It is my impression, however, that we become over-engrossed in these artifacts which are in themselves effects, not causes. Do we need to refurbish our fundamental respect for human intelligence, the cause from which these miracles of accomplishment flow? Our Committee thinks there is damning evidence that we have in many ways lost our respect for our greatest human resource—the God-given talents of each citizen, that intellectual ability which distinguishes us from the rest of creation. Our greatest national crime is the waste of human talent, a waste which points to a conflict between what we say is our American ideal and what is actually happening in practice. Supposedly no one would argue with this principle stated by the President's Committee: ". . . every individual, regardless of race, creed, color or national origin, shall have the opportunity to develop his or her best self, to continue appropriate education up to his or her personal point of optimum development. . . ." (First Interim Report to the President, p. 4.) In other words, ideally in this country every boy and girl should have the fullest educational opportunities subject only to two limitations: a) ability —no one should expect opportunities which go beyond his ability to profit from them, and b) desire—no one has a right to opportunities who is not willing to exert the effort necessary.

A careful, objective scrutiny of our educational system reveals many evidences of the violation of this principle of fundamental respect for the educational rights of the individual learner. Let us examine some of these violations, using the two categories mentioned above: a) violations against the learner's ability, and b) against his educational desire. The most serious attack on the student's ability has been generated by the so-called democratization of the educational process, the inevitable trend towards mediocrity created by undifferentiated programs at every level of our educational system. It is tragic to observe how badly we have missed the rather simple truth that though the creator has endowed all men with equal rights and a common destiny, He has distributed abilities both in kind and degree most unpredictably among human beings.

Given his unique kind and degree of ability, therefore, each boy or girl has a right to the educational experience which will develop that ability to the maximum. Yet, look at the sorry results, for example, in the fields in which you are particularly interested. Because some do not have ample ability or sufficient interest for the study of mathematics and science, these subjects are either not offered at all in many high schools or offered in such a way that it was perfectly respectable even for the talented youngster to avoid them. The result: everywhere engineering students with high I. Q.'s and excellent aptitude for this field are educationally and psychologically unprepared to face the stern tasks required in a vigorous college curriculum.

Respect of Ability

Not only should courses and programs in individual institutions be differentiated according to student ability, but this same principle demands radical changes in the total organizational structure of American higher education. We have encouraged colleges and universities everywhere to engage in what might be considered even radical experimentation. An example might be lengthening the school year to 10 or 11 months, not necessarily to accelerate a student's progress in terms of time saved or to provide more trained manpower for industry and government more quickly, but, more importantly, to enable a boy or girl to profit from a deeper, broader education—the kind of comprehensive grasp of the major fields of learning coupled with adequate specialization which is being sought in engineering and other fields.

Furthermore, we have called for a careful analysis of the very real differences between the levels of education needed within a broad discipline such as engineering. We all know that too many young engineers are finding themselves in work which is not truly engineering in the creative sense, but rather in such important tasks as the highly technical care of equipment, maintenance of complicated gear, and the sale of scientific equipment. For maximum efficient use of our limited teaching personnel, our limited facilities, and especially of the talents of our students, it is wasteful indeed to give those destined to perform at the technological level the same kind and degree of engineering education as is given to those who will be expected to do the topflight creative work on which the profession will always depend.

If technical institutes with two- or three-year programs of respectability and quality were initiated to serve the large numbers needed to carry the burden of highly technical but routine work, then at considerable economic and manpower savings a unified four or five-year program could be provided which would emphasize the basic sciences and all those comprehensive subjects necessary to give a young man that true wisdom which makes him at one and the same time a creative engineer and a well-educated human being. It is fervently to be hoped that engineering leaders in industry will understand the tremendous importance of these new organizational structures in higher education and give these experiments the encouragement needed to test the validity of their objectives.

Here let me emphasize another point relating to respect for ability to which the Committee devoted considerable attention in this study. To be well-educated in this technological age demands not only deeper knowledge for the areas of one's specialization, but what might be called education for leisure. The fantastic advances of which the human mind is capable seem endless in their future potential. With automation moving ever forward, most Americans will be working shorter hours and fewer days per week. The substantial part of a man or woman's life will no longer be completely taken up by working, eating, and sleeping.

Respect for the individual learner then demands either that we educate our young people for constructive use of leisure time or that we assume guilt for contributing to the alarming spread of delinquency, the breakdown of family life, the horrible disintegration and waste that come with long and constant pursuit of cheap entertainment and unhealthy pleasures. Surely the well-balanced engineer we are looking for is the one who has

combined a sound grasp of the scientific bases of his profession with an abiding appreciation of books, art, music, and all those other creative activities which blend the best we can offer in the formation of mind and heart with wholesome forms of human pleasure and entertainment.

Motivation

Thus far, we have considered the need of doing a more effective job in respecting the learner's *ability*. The Committee is of the opinion that much more also needs to be accomplished in developing intellectual *motivation* in our American youth. What are we doing to remove the obstacles to a capable student's legitimate desire to go on to higher educational opportunities? As all surveys have indicated, at least half or more of our highly qualified high school graduates are denied advanced study by financial difficulties.

In general, therefore, our Committee recommends any kind of program which will make funds available for needy students who could profit from a college education. But here again I think we would like to see a new emphasis in the area of student aid. For many reasons, we feel that the major effort should not be in the form of scholarships. I can give only the barest outline of some of these reasons: 1) because the award of a scholarship has acquired a significance related to social status, the whole apparatus of scholarship awards is in a very hectic situation at the present time; 2) scholarships have the defect of being a "hand-out," with the result that the student often lacks a sense of personal investment and the consequent determination to make the best of his opportunity; 3) the amount of money available for scholarships will undoubtedly be at best a "drop in the bucket" compared to the aid needed.

Hence, our Committee strongly urges the rapid growth of sound loan programs, both at the State and local level, on the grounds that such programs avoid most of the objections to scholarship plans. We are convinced that institutions, foundations, and government should endeavor to popularize the idea of a judicious use of credit in financing an individual's education. We also endorsed the development of federally sponsored "work-study" programs at colleges and universities aimed at providing notably able and needy students with appropriate employment at fair wages in the service of the institution attended.

Although I think the Committee might recognize the need for "crash" programs, in such critical times, our general thinking would be opposed to the type of programs which will probably secure Federal support in the current session of Congress. Our Committee, the U. S. Office of Education, the American Council on Education, and other leading educational associations as well as most college and university administrators have generally favored broad, unrestricted scholarships for undergraduates if Federal monies are to be made available. Nevetheless, influenced by the present state of near-hysteria, Congress will probably approve only a program which restricts all or a major portion of the funds to categorized scholarships in specialized fields.

But even if we make great strides toward removing the financial barrier which deters many capable students, we know that there are large numbers of gifted youth who spurn post-high school education even though finances are not a problem. What can we do to remove the obstacle of lack of motivation or malmotivation which today is preventing about half of our most

highly qualified high school graduates from taking advantage of additional educational opportunities? Most of the obvious solutions to this problem involve means which would be effective but certainly undesirable.

First of all, Russia has clearly demonstrated that governmental coercion can guarantee effective motivation. Their system of identifying youth with superior ability, obliging them to continue their education at government expense, and requiring use of their developed talents for governmental purposes obviously has succeeded. Instinctively we reject this possibility, but what can we provide as an adequate substitute in our free society?

"Freedom, in education as in other realms of our national life, is stamped all over American institutions. As a free people we have decided, for better or for worse, to give U. S. schools the character they now bear. If their curriculum is shockingly 'soft' today, we must remember that a whole generation of decisions—many of them unmitigated foolishness—has made it that way. We cannot change it all overnight. Moreover, the changes that we now make must be made deliberately, thoughtfully, without hysteria. Let us, before we make any decisions, face up to the full significance of our present position *vis-a-vis* the Reds. Are we willing to pay the price to overtake them in science and technology? No one should answer that question until he has thought it through. But answer it we must." *America*, Dec. 7, 1957, p. 309.

And this editorial comment brings me to our second alternative in generating student motivation. If we reject governmental coercion, do we honestly wish to continue what seems to have been our motivational method in recent decades? Can we continue to assume that the educational process is merely the passive acquisition of numberless more or less related facts and figures, or, in addition, is there in the process a disciplinary element we have been neglecting? We still recognize that in the physical world (sports, for example) skill can be acquired only by rigorous repetition, constant application of techniques which of their essence require effort and produce fatigue. Why should we continue to assume that the motivation for intellectual accomplishment can be engendered in our students without having them become convinced by experience that part of the very joy of accomplishment is the effort essential for success. What the sage said many years ago is more true than ever: Knowledge maketh a bloody entrance. None of our modern teaching devices, no matter how helpful, can change the essential character of the learning process which must involve the same thrill of almost fierce struggle and competition so common in the physical world.

Disillusioning experience has taught us that, by and large, even those with unusual ability will not exert themselves in an intellectual atmosphere of "sweetness and light" as advocated by progressivism. Furthermore, fear alone will never provide adequate motivation for a sound, continuing philosophy of American education. The natural instinct of fear is essential for human safety, and it is undoubtedly a blessing that we have been scared out of our lethargy for fear that if we do not advance more rapidly in technology we cannot save our skins. But the wise man in Sacred Scripture warns us that fear is only the beginning of wisdom, not wisdom itself. (Ecclesiasticus 1/16/17.) If fear is our sole propellant, then a few years from now, when we have succeeded in launching more satellities than the Russians, we will lull ourselves back into fatal smug complacency.

Here I should like to point out that

"crash" programs not only tend to overplay the unstable motivation created by fear, they also tend to establish motivation based on false premises. While we are all agreed that we must do everything conceivable today to arouse in our youth a burning desire to excel in the knowledge and skills which scientific advancement requires, unfortunately in the minds of many people it is assumed that this means we must withdraw the effort and emphasis hitherto centered on other types of learning and concentrate on the physical sciences. This is not so.

It is false to assume that we are already fully occupying the time and adequately challenging the ability of our students so that the maximum of educational efficiency is being achieved and any change of curricular emphasis must mean a diminution of one area of learning to accommodate another. Rather what is desperately needed is a much better balanced curriculum through addition and enrichment of programs now generally neglected. In the case of preparation for technology, this would mean the addition of substantial programs in basic mathematics and physical science without any need whatever of diminishing the other equally important areas of learning—the humanities and the social sciences. Trimming and de-emphasis should take place only in the case of courses which cannot justify their place on the curriculum because they lack substantial intellectual content and are not well adapted to the development of generalized habits of methodical thinking.

Avoid Extremes

Negatively, therefore, we must avoid governmental coercion and its opposite extreme, the easy-going philosophy of making learning a hilarious game. Likewise, our long-range hopes cannot be based on fear-inspired "crash" programs. The only method I know of developing a nation-wide desire for learning, the only motivation that will keep men and women either as individuals or groups constantly pursuing truth from all available sources is the deep, personal conviction that each of us really does not have freedom of choice as to whether or not he will exert the effort and make the sacrifices necessary to realize the potential of his abilities. Morally, he is no more free to make this choice than he is to decide that since fortune brought him a superabundance of this world's goods, he can decide to throw money away with no regard for his stewardship. Brains are an infinitely more valuable asset than wealth; it is correspondingly more sinful to squander the former than the latter.

In a free society, a man has an obligation to keep that society free by utilizing his talents for the combined benefit of himself and his fellowmen. This kind of motivation must begin early in the home with the indoctrination of a sense of responsibility by a youngster's parents and must be continued without interruption through each year of his education so that by the time he is in high school he has established his own personal convictions about the duty he has before God and his fellowmen to make the best possible use of his talents. High schools and colleges filled with large numbers of young people thus motivated would soon produce unprecedented results.

According to the President's Committee on Education Beyond the High School, therefore, there are three concepts which must be injected anew into our educational system: 1) respect for learning itself independent of its utilitarian value; 2) respect for

the teaching profession as the guardian, discoverer, and purveyor of human wisdom; and 3) respect for the right of individual Americans to differentiated educational opportunities commensurate with their full intellectual and volitional capabilities. This is a gigantic task which will require nation-wide recognition of the problem itself, huge financial assistance from many diversified sources, and the persistent determination not just of educators but of every segment of the American public.

ENGINEERING APTITUDE QUESTIONNAIRES AVAILABLE

A new guidance questionnaire for prospective engineering students, entitled, "Do I Have Engineering Aptitude?" by Dr. A. Pemberton Johnson, Assistant Director of the Counseling Center at Newark College of Engineering, is now available, in quantity, from Engineers' Council for Professional Development.

The cost of fifty pamphlets is $2.00, with a 20% discount on orders of 100 or more.

The pamphlet consists of twelve questions, with answers, and interpretations of answers for use in self-analysis by young men and young women 16–25 years of age who are interested in an engineering career. Typical questions are: (1) "Have my grades in high school mathematics courses been in the top third of my class?" and (7) "Am I interested in the 'why' of things?"

The New Jersey Engineers' Committee for Student Guidance initially offered this pamphlet without charge to about 400 guidance counselors in New Jersey high schools. Upon their request, and through the cooperation of several local industrial concerns, over 12,000 copies have been made available for use in New Jersey. Since last May, when the EJC Engineering Manpower Commission's Newsletter mentioned the availability of this questionnaire, the New Jersey Engineers' Committee has literally been "swamped" with requests from the United States and a number of foreign countries. It is estimated that over 20,000 copies have already been distributed.

Guidance counselors, science club sponsors, deans of engineering colleges, and others interested in selecting potential engineering students will find the four-by-seven inch pamphlet helpful in their work. Requests from engineers, editors, principals, and guidance counselors for single copies of the pamphlet will be honored when on official letterheads and accompanied by a stamped, self-addressed, size 10 envelope. Please address requests to

Dr. Frederick A. Russell, Meetings Secretary
Newark College of Engineering
367 High Street, Newark 2, New Jersey

TRAINING THE TECHNICIAN FOR THE ENGINEERING MANPOWER TEAM

KARL O. WERWATH

President, Milwaukee School of Engineering
Chairman, Working Group on Supporting Technical Personnel, President's Committee on Scientists and Engineers

Introduction

The advancing technology in the United States is calling for an enlarged and broadened team of technical specialists. Occupations in the technical endeavors fall into a broad spectrum, from the craftsmen on the one hand to the scientists and engineers on the other. To our best calculations we now have about 9,000,000 skilled craftsmen who apply scientific and engineering principles to the building processes, assembly lines, production work and trade and service functions. On the other end of the spectrum are 950,000 scientists and engineers—the creative team which now makes up ½ of 1% of our total population. Between these two extremes of the spectrum of our engineering manpower is emerging a new occupational group, called "The Technician." It is our purpose here to review the characteristics and role of this type of manpower in America today. It is estimated that for each engineer we need five technicians. Among these are the engineering technicians—supporting personnel to engineers—in whom we are particularly interested in this discussion.

What Qualifications Do We Look for in an Engineering Technician?

Specifically, the 1953 report of the Recognition Committee of the Engineers' Council for Professional Development defines the Engineering Technician as follows:

"An engineering technican is one who can carry out in a responsible manner either proven techniques which are common knowledge among those who are technically expert in this branch of engineering, or those specially prescribed by professional engineers. Under general professional engineering direction, or following established engineering techniques, he shall be capable of carrying out duties which may comprise: working on design and development of engineering plant; draughtsmanship; the erecting and commissioning of engineering equipment or structures; estimating, inspecting and testing engineering equipment; use of surveying instruments; maintaining engineering machinery or engineering services and locating faults; operating, maintaining and repairing engineering plant; or activities connected with research and development, sales engineering and representation, servicing and testing of materials and components, advising consumers; and training and education.

"In carrying out many of these duties, the competent supervision of the work of skilled craftsmen will be necessary. The techniques employed demand acquired experience and knowledge of a particular branch of engineering, combined with the ability to work out the details of a job in the light of a well-established practice.

"An engineering technician, therefore, requires a background sufficient to enable him to understand the reasons and purposes of the operations for which he is responsible."

Referring to the scientific and engineering technician, a statement incorporating these qualifications was developed for us by the Working

Committee for the Development of Supporting Technical Personnel of The President's Committee on Scientists and Engineers:

"The scientific technician and the engineering technician have become a necessary part of the American industrial team, with ever-increasing responsibilities. The scientific or engineering technician generally works in one of three areas:

1. Research, design, or development;
2. Production, operation, or control;
3. Installation, maintenance, or sales engineering.

"When serving in the first of these functional categories, he directly assists the scientists or engineer. When employed in the second category, he executes a plan laid out by the scientist or engineer but does not usually work under direct supervision. When active in the third category, he frequently does what would otherwise have been done by the scientist or engineer. In our growing technologically based economy, the scientific or engineering technician must have a background in post-secondary school mathematics and the principles of physical and natural science, which makes it possible for him to understand and communicate scientific or engineering data, mathematically, graphically and linguistically."

More recently, the Project Committee of the National Survey of Technical Institute Education, conducted by the American Society for Engineering Education under a grant from The Carnegie Corporation, has evolved the following newer definition of "Engineering Technician":

"In general, the engineering technician is a person whose interests and activities are directed chiefly toward the testing and development, the application, and the operation of engineering or scientific equipment or processes. Classified on the basis of educational certification, the engineering technician would be a graduate of a technical-institute type of curriculum as accredited by Engineers' Council for Professional Development, or recognized equivalent. Classified occupationally, the engineering technician performs semi-professional functions of an engineering or scientific nature, largely upon his own initiative and under only general supervision of a professional engineer or scientist.

"Typical among the wide array of semi-professional functions performed by engineering and scientific technicians are: Drafting, design, and development of products and of engineering plant; testing, installing, inspecting, operating, and maintaining engineering or scientific equipment; and estimating costs, selling, and advising customers on the use of engineering or scientific equipment.

"In many instances, the technician may serve as a liaison between the engineer or scientist on the one hand, and the skilled craftsman or layman on the other hand. In carrying out these various activities, he may have group leadership responsibilities. The technician must be able to communicate mathematically, scientifically, and linguistically."

While the engineer plans, the technician makes and does; while the engineer creates, the technician applies. This engineering technician is often the liaison between the professional man and the craftsman. He has the same basic characteristics and fundamental educational requirements as the engineer, except that his interest and education are more in the direction of application, with less mathematical and theoretical depth, combined with the ability to understand the instructions of the professional engineer and translate these to action either by applying his own abilities or in the direction of other suporting technicians and craftsmen.

What Are the Specialized Fields of Technology in Which Courses Are Offered?

There are some 100 courses accredited by Engineers' Council for Professional Development or approved

by the National Council of Technical Schools in ten fields in which engineering technicians have become prominent and in which technician employment opportunities have demanded course development. These fields include aeronautical design, maintenance and production; air conditioning, heating and refrigeration; architecture and building construction, civil technology; electronics and radio-television; electrical power and control; instrumentation and watchmaking; metal fabrication and tool design; photographic; and steam, diesel and automotive technology. In addition, there are some seven other miscellaneous highly specialized fields listed in the 1956 College Blue Book, such as gas fuel technology, fire protection, industrial technology, stationary engineering, surveying technology, chemical technology, and welding technology.

What Is the Nature of the Content and Presentation of Those Courses?

This type of instruction is in the broad area of technical education and lies between professional engineering on one side and vocational education on the other and is conducted by several types of institutions. Curricula are offered by one or more schools in the following categories:

- Technical institutes, endowed or publicly supported.
- Proprietary schools, operated by individuals or corporations.
- Junior colleges offering terminal programs.
- Evening sessions and extension divisions of colleges and universities.
- Schools or training divisions associated with industries.
- Specialized schools operated by divisions of government.
- Correspondence schools.

Courses are from one to three years in length but generally require two academic years of full-time study. High school graduation or equivalent is required for admission and most courses have specific additional academic matriculation stipulations. These programs are briefer and more technical in content than are professional engineering curricula. They include a heavy schedule of specialized technical subjects which make up approximately one-half of the curriculum in class time and total student effort. These are integrated with and balanced by related studies in mathematics, physical sciences, graphics, English, economies, industrial commerce and general studies. Such courses now generally lead to an Associate Degree in Engineering or Applied Science.

This is a specific type of higher education leading to specific occupations. Transfers from technical institute to other curricula or from one technical institute curriculum to another are relatively few. Credits are generally transferable for comparable subject matter.

Technical specialties and other subjects are evaluated individually and credit toward a baccalaureate degree will vary from full to partial, depending upon the policies of the accepting institution. More credit is usually gained when the technical institute course is integrated under a concentric curriculum or as a part of a formal combination program.

The pattern of successfully established programs have two basic, distinguishing factors. First, a technical institute curriculum is planned around the technical specialties and a neatly integrated combination of supporting subjects, both geared to dynamic industrial requirements. It is a specific form of higher education and is not a combination of skill training courses

with some aspects of broader education. Second, the course also takes into account that the engineering technician, in executing his work, is a part of management. His education, of necessity then, also includes such training as is required of a leader in a free-enterprise technological environment.

In What Ways Can Technical Schools, Industry, and Professional Societies Combine Efforts?

1. Conceive and control basic policy in an influence conducive to good relations with industry.
2. Review on a regular schedule course outlines, subject content, and faculty development by industrial advisory committee composed of representatives of industry.
3. Augment regular faculty with guest lecturers, particularly for highly specialized technical material.
4. Select teaching personnel for practical industrial experience as well as academic background and teaching experience, and, in some instances, include such personnel as is supplied by industry on a loan basis.
5. Work with industry and technical societies in the development of instruction aids and laboratory equipment.
6. Develop a strong relations-with-industry program to work with industry on job opportunities for part-time and cooperative arrangements.
7. Maintain a full-time placement service for proper placement of graduates.
8. Conduct applied industrial educational research in conjunction with industry.
9. Conduct regular field trips to convey specific information, especially in scientific and industrial operations and organizations.
10. Establish a program so that educational administration can have a continuous source of ideas from professional and technical societies, trade organizations, alumni, and industry.

To What Extent Do Your Graduates Meet the Present Demand for Technicians?

There are various estimates as to the need for engineering technicians in proportion to engineers. The American industrial nation requires about 200 four-year engineering graduates per million population to parallel closely the existing ratios of other modern industrial nations of the world. As for supporting technical personnel, our studies point up the need for five technicians per engineer on the engineering team. One of these five should be an engineering technician produced through a technical institute type program. This would call for approximately 35,000 such technicians per year. Last year some 11,350 were graduated from courses in 66 schools. To meet the need, technicians have been developed through other sources, including evening programs and on-th-job training. It is safe to say that the shortage of technicians is even more significant in America now than the shortage of engineers.

As technology advances, the proportion of higher level engineering technicians will increase. Graduates from 2-year accredited technical institute curricula should increase ten-fold in the decade ahead.

That there is a shortage in the nation's requirements is emphasized by The President's Committee on Scientists and Engineers' Report:

"A. The fact that there is a shortage of scientists and engineers, and that the ratio of technical to the whole labor force is rising, indicates a continuing and probably a growing demand for the skills of scientific and engineering technicians.

"B. The Department of Labor currently lists a number of these technical skills on the 'Critical Occupations List.'

"C. The experience of the Working Committee indicates that competent graduates of engineering technician schools receive many offers of jobs and that salary levels are rising.

"D. Fragmentary local data indicate that there are more jobs than applicants in most instances checked. One large firm reports successful hiring of only one-third of its expressed needs for 1956.

"E. Many technical schools are now supported in part by industry and public agencies to assure a flow of trained technicians. Demand has forced the development of technical institute type curricula in the major fields.

"F. Industrial advertising in newspapers, technical publications, school newspapers, and handbills and other media is evident in almost all major industrial centers.

"G. Despite extensive training programs and various improvements in career incentives, the military services are faced with persistent shortages of technicians who are urgently needed to man and maintain our complex new weapons systems. The military services are constantly losing such people to industry, which also needs them. The problem is national in scope. Increased training to improve our supply and quality of technicians is, therefore, necessary to meet national defense needs as well as those of a healthy civilian economy."

In analyzing technical institute education in the United States for the academic year 1951–1952, we find that of some 100,000 male pupils leaving the first level of education (that is the 6th grade), after completing high school approximately 33,700 entered higher education. Of these 3,630, or 10.7%, entered engineering and 1,090, or 3.2%, entered technical institute education. This produced, after the attrition of four years, 2,450 baccalaureate degree graduates and 910 technician certifications. To attain proper proportions and thus retain our position in a growing technological economy, we in the United States must develop talent to produce annually a greater number of engineers and up to ten times the number of qualified technicians during the next decade.

The opportunities in this field open a broad choice of careers for hundreds of thousands of Americans who can also make a real contribution in advancing the interests of a strong, healthy economy and in strengthening the national defense.

SUMMER PROGRAM IN SCIENTIFIC EXPERIMENTATION

The Massachusetts Institute of Technology will offer a Special Summer Program in the Design and Analysis of Scientific Experiments during the 1958 Summer session, from Monday, August 4 through Friday, August 15. The program will deal with the application of the laws of chance to the design and analysis of scientific experiments.

Further information can be obtained from Professor Harold Freeman, MIT, Cambridge, Massachusetts.

MUTUAL INTERESTS OF INDUSTRY AND ENGINEERING EDUCATION

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The 1958 College-Industry Conference was the 10th sponsored by the Relations With Industry Division of the American Society for Engineering Education. Two hundred representatives of employers and a little more than two hundred educators met to hear papers bearing on the mutual interests of the two groups. It seems to me that the tone of the conference was accurately recorded by a representative of a professional association who reported in his journal,[1]

"For nine years before the sputnik beep-beeped its message to the world, engineering educators, practicing engineers, and other executives had held annual conferences to review the problems and progress of engineering education, its supporting sciences and its public significance. The conferences were open. The information was public. But the public was not ready to be informed, or to give the support invited.

"In dealing with a now popular subject, the 10th annual conference proceeded in its characteristic atmosphere of cool, practical, realistic objectivity. It was a refreshing relief from the alarmed clamor, name-calling, and blame placing reactions of spokesmen for the public who have recently awakened to a sense of personal peril."

Topics and Speakers

While the atmosphere of the conference was "cool, practical, realistic objectivity," the speakers introduced many notes in harmony with the theme, "New Concepts in the Education and Development of Technical Manpower." One of the most popularly received talks was the opening address by Reverend Paul Reinert, S.J., President of St. Louis University. His forceful plea for increased respect for learning, for the teaching profession, and for the learner's right to differentiated educational opportunities reflected the thoughts of the President's Committee on Education Beyond the High School on which Father Reinert had been active for the past two years. His advocacy of equal pay for equal teaching performance was a concept that engineering deans undoubtedly wish to regard as "new" and unrealistic when they are presenting budgets to the administration, at least during years when the supply of engineering teaching talent is low compared with the supply of talent for teaching non-engineering subjects.

Kenneth Holderman, Assistant Dean of Penn. State University, did an excellent job of putting technical institute education into a suitable perspective so that educators, employers, and prospective students could more effectively utilize this relatively new segment of American education. A paper by Andrew Kucher, Vice President of Ford Motor Company, stressed the importance of keeping engineering and engineering education up-to-date. He pointed out the inevitable weakness of education motivated by fear or pleasure and emphasized opportu-

[1] Ralph A. Palmer, Treasurer and Assistant Secretary, American Society of Agricultural Engineers.

nity for American education "to develop the opposite tendency, to encourage and train the belief in duties and obligations and to inspire devotion to better things than those to which we are drawn by our lower instincts." One conferee from 2000 miles away commented, "This one paper was worth the entire trip."

Many of the concepts new to engineers and engineering educators were introduced by Professors Pelz, Danielson, and Riegel, of the Survey Research Center and the Bureau of Industrial Relations of the University of Michigan. The written evaluations of over 100 of those attending the conference brought many comments such as "these three presented new information based on considerable research," "pioneering in concept," "pointing the way to a better understanding of our problems," and "this group constitutes the biggest intellectual challenge to me."

Arthur S. Flemming, President of Ohio Wesleyan, brought to the conference a background of personal experience in the top level considerations our nation has given to the problems of defense. He ably advocated that we continue our efforts to be a strong nation, but that we must also "provide the kind of spiritual leadership without which peace in our time is but an idle dream."

The session on "Professional Development" brought summaries of such activities at King Seeley, Western Electric, Whirlpool-Seeger, and Dow-Corning. The most frequent comment on this portion of the conference was that there should be more time for the interchange of ideas and for a thorough discussion of these problems. Reuben G. Gustafson, President and Executive Director of Resources for the Future, brought the conference to a fitting close. His main points were that we need to be devoted to the encouragement of scientific curiosity and to be conscious of the social problems and responsibilities that inevitably follow intellectual development. A typical industrial representative reported, "I felt that this talk was the inspirational high point of the conference."

The impact of the conference is best measured by reporting that 61 employer representatives and 58 educators took the trouble to fill out a questionnaire on their evaluation of the conference. Practically 100 per cent of these replies made suggestions for future conferences in addition to answering the routine questions.

Employer's Suggestions for 1959

The enthusiasm of employer representatives for more opportunities for the study of the mutual problems of industry and engineering education is evident from the number and a variety of topics proposed for future conferences. These included: how industry can improve professional development by providing greater breadth of assignments, a study of correlations between academic achievement and subsequent achievements in industry, the possibilities of developing tests that will measure academic achievement and that can be given on a nation-wide basis, how we can increase flexibility in recognizing academic achievement regardless of how it has been obtained, how industry and engineering colleges can work together to keep graduates from becoming technically obsolete, criteria for sound industrial scholarship plans, roles of the engineer in today's society, how to improve technical recruitment, an economic study of the justification of employing women engineering graduates, a thorough delving in depth into the

problem of utilization of engineers, techniques of motivating technical personnel, industry's role in orienting engineering students, how colleges can better prepare students for manufacturing engineering, how to cultivate creativity, how better to motivate and develop technical supervisory talent, further careful study of how to improve part-time education at various levels and under a variety of situations such as are encountered in large and small industries, and finally, how industry can help most effectively in this time of intense concern for our educational system.

It is evident that many leading employers of engineers make a year-round effort to interchange ideas with engineering educators. In addition to using the College-Industry Conference as a refresher they send numerous representatives to the ASEE annual meeting. They are represented at the sectional meetings in all geographical areas where they have activities. They are active in the work of committees and councils of the Society.

It was also evident that the College-Industry Conference and other ASEE activities are a new experience for some of the employer representatives. A number of employers have become Industrial Members of ASEE as a result of contacts at the 1958 College-Industry Conference. These new members are planning to increase their year-round contacts with engineering colleges and to give greater breadth to their study of how to improve the utilization of technical personnel.

Educator's Suggestions for 1959

It is also evident that engineering educators want more opportunities for an interchange of ideas with employer representatives. Some of the topics they want discussed in the near future are: Interchange of personnel between research teams in industry and college faculties, Further discussion of what employers want in engineering curriculums, The place of the "physicist-engineer" or "engineer-scientist" in industry, Possible expansion of cooperative engineering education programs, Possible use of employed engineers for teaching assignments, How can the small engineering college participate in industry sponsored research?, What can engineering colleges do to help in the continued education of graduates after they enter employment?, and What should engineering colleges do to develop programs for educating engineering aides?

It is evident that a great deal of enthusiasm will go into the development of the 1959 College-Industry Conference to be held January 26 and 27, with the University of Houston serving as host. It also seems likely that the Relations With Industry Division of ASEE will give serious consideration to the development of regional or section activities which will help in solving the mutual problems of engineering educators and employers of engineers.

CAN INDUSTRY ASSIST IN ADVANCED ENGINEERING EDUCATION?

FRED B. HAYNES

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Last September, one hundred and seventy-odd Martin employees registered in the Drexel-Martin Graduate Engineering Program leading to degrees as Master of Science in Electrical Engineering, Mechanical Engineering, Aero-Engineering, and Physics. It would have been impossible for most of these people to take up such work, were it not for this unusual educational program, of which last fall marked the beginning of the second year.

From the academic standpoint, the program is operated exclusively by the Drexel Institute of Technology, located in Philadelphia, but instruction is offered in facilities provided by The Martin Company in close collaboration with the Baltimore County Board of Education. The classrooms are located in Kenwood High School, near the Martin plant.

General Factors

Much has been said in the press about the shortage of engineers and scientifically trained people in this country. Concern has been expressed about the relative number of engineers being trained in the U.S.S.R. as compared to the number being trained here. Even more disquieting is the prediction as to what the relative numbers will be in the next few years.

Solving the general problem of engineering education has many facets, and begins at least as early as the first year of high school. It is usually too late to do much about it during the senior year; hence there is a crying need for intelligent counseling. If potential engineers are to be ferreted out, the counselor must have some knowledge, preferably first hand, of what engineering really is.

Next comes the high school curriculum itself. Does it provide proper training for college courses in engineering? If so, are the courses supported by adequate teaching staffs and facilities?

In the engineer's development, college training has enjoyed the major share of public attention because this phase lies nearest to the end product. The man with a B.S. in Engineering is entirely too scarce in relation to the demand—and the demand has become most urgent. Unfortunately, very few of our colleges and universities are capable today of handling much larger enrollments in engineering without additional facilities and faculty members.

Need for Advanced Study

After the engineer has accepted a job, generally in some industry, he soon becomes aware of the fact that his training is inadequate to handle the work he would like to do and that his company wants done. This need for advanced study is much more acute than is realized by the general public or, perhaps even by some of the colleges themselves.

It is no longer merely the matter of an advanced degree to enhance an engineer's prestige and to help him command a higher salary. It is a case of advanced training to enable him to do

the work demanded of him. Industry and the nation *must* have more advanced engineering training to keep us abreast of technological developments in the world. The urgency grows daily and there seems to be scant possibility of its diminishing in the foreseeable future.

With the need of the individual, of industry, and of the nation for advanced training for engineers, it is clearly the responsibility of the engineering colleges to find an answer. Only a cursory investigation is required to establish the fact that our present facilities are entirely inadequate and that new ways and means of providing and supporting them must be discovered.

An Approach to the Problem

Let us attempt a wholly unbiased, scientific examination of the situation. First there is the engineer, the potential student. Generally he must work at his vocation to earn a living. His major incentive to "get ahead" is depreciated if he can afford to quit work. Evening graduate studies become almost mandatory as a supplement to long-range industry-supported resident programs.

From the student's standpoint, then, classrooms should be conveniently located. He has had to ride a long way to work and back home. An additional trip seems particularly distasteful. He has to continue this for many months. It is well to remember, too, that it is easiest to contact such students in groups where they work.

A second and highly important part of this problem is the assembling of an adequately trained teaching staff. Many potential instructors in engineering have been lured away from the campus to industry by the simple device of more pay. This solves industry's problem temporarily, but in the long run it compounds the difficulty of producing the younger engineers that production must have. Industry is becoming more and more aware of this as higher and higher beginning salaries are paid to attract trained personnel.

A third ingredient of this problem is the matter of classroom facilities. Because of present bumper enrollments at both the undergraduate and graduate levels, existing college-campus facilities are taxed to the limit.

A Solution

If certain conditions are recognized and allowed for, this problem can be solved readily for a large segment of our engineering population without the expenditure of large sums of money and without government assistance. These conditions include the following:

1. Recognition by industry of the need for advanced engineering training.
2. Recognition by the colleges and universities of the need for advanced engineering education and of their responsibility to fill this need.
3. Willingness on the part of educators to discard some of their traditional thinking in favor of a more dynamic and realistic approach.

In the minds of those closely associated with it, the Drexel-Martin program represents a solution to the problem which meets fairly the basic requirements of the student, of industry, and of our institutions of learning.

Program Initiation

In the late spring of 1956, the Martin Company requested the Drexel Institute to consider setting up a special graduate school in engineering for the exclusive benefit of Martin employees. Martin believed that teachers and classroom facilities could be provided.

When confronted with such a decision, the first thing which crosses the collective minds responsible for the destiny of an educational institution, is whether or not the most precious ward under their guardianship—namely, academic standing—will be compromised. This may be particularly true when the institution and the industry are physically located some distance apart.

Even if the industry is willing to underwrite such a program to the extent of guaranteeing against any loss to the institution, a good deal of courage, supported by the foresight to distinguish the long range benefits to be gained, is still required to have a university or a college join hands with industry in such a venture. Fortunately, part of the stage had already been set through earlier cooperative programs between Drexel and Martin. Mutual respect and understanding established through these experiences did much to hasten the implementation of the program.

The basic agreements between Drexel and Martin were simple: (1) a graduate engineering program would be established at Martin by Drexel, with a guarantee against financial loss to Drexel; (2) the school would be operated solely by Drexel on identically the same basis as the graduate school on the campus in Philadelphia; (3) the instructors would be recommended by Martin, but selected and hired solely by Drexel; and (4) classroom space would be furnished by Martin at or near the company's plant.

Although these basic agreements formed a pattern of operation, many details were left to be worked out. Some of these are outlined here, in the hope that they may be of some value to those who may contemplate a similar cooperative program between an educational institution and industry.

Implementation

First a questionnaire was sent to all members of the Engineering Division at Martin by the company's Supervisor of Engineering Education. This form asked three basic questions: (1) would you be interested in taking graduate work leading to the Master of Science degree in Electrical Engineering, Mechanical Engineering, or Physics?; or (2) would you be interested in teaching courses in these fields? and if "yes" to either, (3) what are your qualifications?

From the answers to these questionnaires it was possible to estimate the number of potential teachers with suitable qualifications in the desired fields. It should be noted that the list of potential instructors was not limited to the employees of the Martin Company. The list was screened, jointly, by the chairman of the Graduate Program and the Supervisor of Engineering Education—the number being based on the estimated number of sections obtained from the student questionnaire.

The names were submitted by the chairman to the faculty heads concerned, and the complement of new instructors was established on the identical qualification basis as that currently obtaining at Drexel. A surprisingly large number of those with graduate degrees had previous teaching experience. The candidates were sent to the Drexel campus, where their respective department heads explained the contents of the courses in some detail and discussed the texts to be used during the first year.

In the meantime, the Martin Department of Education mailed information about the graduate courses offered that fall to employees qualified for registration. This was supplemented by a brochure containing pertinent excerpts from the Drexel Graduate Catalog. In addition, nearly

1000 copies of the catalog itself were distributed.

Regular Drexel "Application for Admission" blanks were filled out in duplicate by the prospective students. One copy was retained at the plant and one forwarded to the Admissions Office in Philadelphia. Each student had already requested a transcript of his record to be forwarded to Drexel by the institution from which he was graduated.

Through the cooperation of the local Board of Education, Martin had been able to secure the use of excellent classroom facilities in a new high school. This was possible because all classes are held in the evening.

On registration day, the Heads of the Departments concerned, plus representatives from the Drexel Comptroller's and Registrar's Offices, were present at the plant. Formal registration was carried out with the assistance of the Martin Department of Education.

Most of the students elected to use the payroll deduction plan provided by the Company, and Drexel billed Martin for these payroll deductions. Instructors are paid directly by the Institute and are given the same faculty rank they would have were they teaching on the campus. Frequent meetings of Department Heads and instructors are held, and personal contacts are encouraged.

This year, special emphasis has been placed on the teacher-exchange program. Instructors of the Drexel-Martin staff go to the Institute's campus each week to teach courses normally taught in Baltimore, and members of the regular Drexel staff go to Baltimore to teach the identical courses. At present, four of the program's twenty teachers are involved in the exchange.

Other Benefits

Many important by-products may evolve from such a cooperative program. In fact, the areas of mutual benefit and satisfaction are limited only by the imagination of the industrial firm and the educational institution concerned. As a corollary, of course, such a program cannot endure unless both parties receive a large measure of benefit and satisfaction.

Those directly associated with the program, both at Drexel and at Martin, feel that (1) the major needs of the engineer and of the Martin Company for advanced engineering education are being fulfilled; (2) Drexel is giving additional educational service to the nation in engineering, service which would not otherwise be possible; and (3) qualified engineers and instructors are being utilized in the teaching profession who otherwise would be wholly lost to the thin ranks of faculties in engineering.

WELDING FELLOWSHIP

A fellowship in welding engineering has been established at Ohio State University, supported by a grant to the university's development fund from the Air Reduction Co. Designed to encourage graduate research and study, the fellowship will carry a stipend of $2,400 for unmarried, and $3,000 for married students. Inquiries can be addressed to Professor Roy B. McCauley, chairman, department of welding engineering, Industrial Engineering Building, Ohio State University, Columbus 10, Ohio.

THE YOUNG ENGINEER AND HIS PROFESSIONAL CAREER

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The author is indebted to the Office of the Secretary of the Army for a Research and Study Fellowship, 1957–1958, which made possible the development of this paper at the Massachusetts Institute of Technology. His conclusions are fully applicable to the young engineering teacher.

The young engineer tackles his first job with enthusiasm. He wants to make a showing and do it quickly. Without realizing it, such early reaction very well may lead him into the pitfall of working *for himself* rather than *with* his associates of the organization. He should understand that he is engaged in teamwork rather than a race for individual recognition. Being smart he finds his place on the team. As he gains a foothold in practical experience, the young engineer begins to see in a modern engineering organization an amplifier for leadership. He learns from his associates, and by observation of the operations as a whole, he soon discovers that he is a definite part of the organization which is eager, in most cases, to aid in the development of his professional career.

Professor Erwin Haskell Schell of Massachusetts Institute of Technology states "The world is friendly to beginnings and to beginners especially if they are young men."[1] In general this is true, but sometimes it is found that the "old timers" in the organization, particularly the engineers who started working during or prior to the depression years, have a resentful attitude toward the young engineers. The "plush" treatment often given to the young engineers by many organizations quite frequently is not accepted graciously by the older engineers in the lower supervisory bracket. The natural tendency for engineers of vision, however, is to welcome the young engineers into the organization.

[1] Erwin Haskell Schell, *Technique of Administration*, Second Edition, McGraw-Hill, page 15.

Cautious Open-minded Approach

The young engineer should "feel his way," have an open mind, be alert at all times, and ask questions (after analyzing all the data and information available). Top supervisors are busy people but usually the bigger the man the more he is interested in the queries, attitude, efficiency and progress of the young engineer. It is very important to take advantage of the friendly interest and opportunity to make contact with men in the organization.

The older engineers who may resent the appointment of the new man in the department may be converted to a friendly attitude by the young man showing extra courtesies to the senior personnel. The junior engineer should always be respectful of the older men for their knowledge and experience; even though they are not in agreement at all times. The older men can be invaluable when the channels of communication are kept open through a friendly attitude.

Generally young engineers are prone to express their opinions with-

out full knowledge of the situation. "Sounding off" at the wrong time can be disastrous. "Snap decisions" may lower the prestige of the young man in the eyes of his senior. As a result the older man may not bother to ask the younger man for subsequent thoughts or comments on important matters. It is desirable that the new employee avoid major decisions until he has gained a thorough acquaintance with each problem, the only exception being in case of an emergency involving the protection of life and equipment.

Many decisions are based on the current circumstances and involve such subjective factors as people and their emotions. The effectiveness of decisions depends largely on the judgment, intuition, foresight, and tact of the engineer.

The capacity for sound judgment, like native intelligence, cannot be created in an individual, although it definitely may be developed, refined and sharpened. The young engineer should learn to weigh the circumstances and analyze all aspects of the question or problem. He must be able to place each phase of a situation in its proper place and be able to forsee and estimate, to the greatest extent possible, the consequence likely to result from each step taken in the solution of the problem.

We cannot entirely divorce ourselves from the past. A young engineer learns from experience and it is very important that he be conscious of the mistakes he has made in order that he does not make them again. However, he should not dwell upon these mistakes thus precluding clear thinking for the problems at hand and circumstances in the future. Past errors are not pleasant to remember, but a good engineer admits his mistakes if he is smart. Honesty and straight forwardness counts heavily in the relationship between the engineer and his subordinates. Refusing to acknowledge past mistakes can indicate the engineer is not entirely sure of himself. On the other hand, an engineer should not be over-conscious in confessing his short comings or his associates may lose confidence in his ability. As Professor Paul Pigors stated recently in one of his classes at Massachusetts Institute of Technology "Past difficulties and differences of opinion should not be considered as setbacks, but rather as opportunities to work more effectively with other people."

The young engineer should be given plenty of room to grow. He should be given a chance to attack and to solve problems. Mistakes will be made, of course, but people learn earlier in life from mistakes than from successes. Also, mistakes made early are a good shield against making more expensive ones later.

Goals and Opportunities

The young engineer on his first job after graduation is like the tourist who lost his way and asked the southern native for directions. The native, after careful thought, said, "Well suh, you begins from heah." Where the young engineers goes from his first job is up to him. If he is endowed with definite qualities of leadership and technical ability, the following of well defined directions and sound principles of professionalism will lead him to opportunities far beyond his expectations.

Opportunities do not just appear, but come as a result of recognized accomplishments. As Mr. Albert S. Redway stated in a talk before an informal group in Cambridge, Massachusetts, on October 4, 1957, *"Wait* for something to turn up, and it is safe to bet you'll find yourself underneath when it does turn." The junior engi-

neer must be watchful of opportunities, challenge, and incentives. A good motto could well be, "Seize the Occasion!"

The progress of engineers in salary and achievement is rapid for the first fifteen years after graduation and then levels off, somewhat less in the higher salary groups and more in the lower salary groups.[2] As the young engineer enters this fast race, he should have the right attitude and determine his goal objectively. A dreamy and indefinite desire for success accomplishes little: the more specific it becomes, the better the chance of obtaining it. What the young engineer makes of his career depends on how he develops his abilities, cooperates with his associates, improves his personality and utilizes the "breaks" that come to him. Many of these "breaks" come through participation in activities of the professional societies, civic groups, churches, schools and other community organizations. The young engineer should discipline himself to make wise choices, positive thoughts, earnest effort and such sacrifices of time and money as such action may require. In so doing, he will leave after him a heritage worthy of the opportunities earned by him.

Growth in the Organization

A thirst for knowledge is an attitude which must be possessed by any young enginer who hopes to succeed in his chosen field. He must have an active native inclination to delve into the fundamental truths. This desire for knowledge must be a continuous thing, as he works with his associates who are a rich source of information and ideas.

A successful career cannot be achieved alone. Collaboration with the engineers of the organization is an intelligent means of drawing from their knowledge and experience. This requires that he work harmoniously with people of different views. A democratic group draws upon all resources available; collaboration in such a group is worth while and normally leads to higher morale.

The executive engineer usually maintains very little data in his own office as he knows who to call upon when in need of information. In the development of information and data by the young engineer for his superior, two points should be borne in mind—(1) The significance of the data and (2) The use to which it will be placed. The best data and presentation, if not put to use, are valueless; and to attempt to utilize information of negative significance is futile. Well developed data presented to the supervisor in a confident sincere manner aids substantially in the advancement of the young engineer's professional career.

Assuming Responsibility and Prevailing Problems

As the young man grows in the organization, he is called upon to assume more and more responsibility. With responsibility comes problems. A solution of some seems almost impossible, especially those involving ticklish personnel matters. Human personalities sometimes pose unsurmountable obstacles and all the knowledge and experience of an undaunted leader are needed in order to cope with the situation.

The executive's job is supposed to be desirable, but it is also tough. If a young engineer aspires to be the boss some day, it may be well to carefully check himself in advance and see whether he has what it takes, or

[2] Harry Rubey, Professor Emeritus, University of Missouri, *The Missouri Engineer Magazine*, July 1957.

can develop what it takes, to be the top executive engineer. Executive duties are so manifold and the abilities they require so diverse, that practically no one can fill the job perfectly. However, executive positions do exist and men must be selected to fill them.

Any long professional career will invariably pass through periods of stress and cycles of unpleasant relations with superiors and associates. Appointments and assignments are occasionally made which entail working with superiors whose personalities a young man cannot understand. Life may sometimes be almost unbearable. Such experience challenge us to rise above personalities and take actions which we feel are just and proper in spite of the prevailing situations and circumstances. Although it is difficult to realize at the time, the living of these experiences provides means of growth and character building.

A veteran civil engineer, the late D. A. Gibbs of the U. S. Army Corps of Engineers, Kansas City, once told a group of young engineers many years ago, "The rough experiences are the ones remembered and laughed about later in life." The days that run smoothly without incident are soon forgotten. Time mellows many errors, raw deals, and unhappy experiences which cause mental anguish to many ambitious engineers.

Recognization of Full Development

Men do not become chief engineers or presidents of firms solely because of their technical knowledge or academic training. They must have the ability to think and speak in an articulate manner. (Articulation should not be confused with oratory.) The engineer should be able to adequately convey the results of his own thoughts together with the essential aims, plans, and proposals which he has diligently developed. Unless a presentation is well prepared, readily understood, and relatively interesting it will not sustain attention. In order for an engineer to properly represent his organization, he must be able to think and speak lucidly. The ability to write clearly and concisely is just as important. Every young engineer should give consistant attention to this very important phase of his self training.

If the young engineer is employed by an engineering firm which performs engineering consultant services, he will find that negotiation is an essential function of the organization. In fact, the existence of the consultant firms depends in many cases upon successful negotiations with prospective clients. Accordingly, the young engineer may be exposed to negotiation procedures early in his career. Normally, the negotiations are carried on by the senior members of the organization; however, assistants frequently attend the negotiation conferences to receive training and also to become familiar with the contractual details to be taken care of upon conclusion of the negotiations.

Some individuals are born negotiators, and others must acquire the ability. In either case, the individual must be a leader with poise, tact, and diplomacy. He must radiate confidence and honesty and have facts available for backing up his proposals. High pressure salesmen as well as negotiators are temporarily effective, but are not conducive to lasting engineering business. As Professor Schell states, "Long-term business relationships are not the product of forced concessions. Unless negotiations strengthen confidence and friendship, they can have only short-term value." [3]

Progress in the young engineers

[3] Erwin Haskell Schell, *Technique of Administration*, Second Edition, McGraw-Hill, page 173.

career may bring him into the role of a mediator, in view of the prevelance of employee-management problems in large organizations. This is a tough job which is done well by a limited number of engineers. Mediation taxes the mental faculties to the limit, involves considerable nervous strain and requires maximum discipline of emotions. Although the young engineer may be lacking some in experience, he is in a good position to be a mediator as he probably has not been with the organization long enough to become biased or prejudiced in his opinion. He must, of course, have confidence in his ability to bring opposite elements together. Likewise, the personnel with whom he is dealing must have trust, respect and confidence in him. He must be a good and patient listener in order to obtain all the available facts and evidence; then be able to weigh, analyze and decide which facts are pertinent to obtaining a satisfactory and equitable agreement.

Realization of Community and Public Relations

The young engineer should realize that there is something good in every person; however, of course, there are some with which he prefers to associate with more than others. This is especially true after he grows to know them better. During the early days in the organization, the new employee should be somewhat cautious about becoming intimately associated with various individuals until he is able to become fairly well acquainted with their character and reputation in the community. It is very easy to become involved with elements, and quite difficult to back away from situations after becoming socially obligated. It is better to be friendly in a casual way with all rather than intimately with a few until the various personalities are known.

In this crowded busy world of ours, nearly every thing we do causes someone else to think good, bad or indifferent about us. The sum total of the attitudes of various people toward us or our organization has come to be known as our "public relations." What we do to understand, improve or alter those attitudes then becomes a public relations effort.

The young engineer should learn early in his professional career that the community's opinion and good will toward him and his organization are very important. He must take part in educating the citizens of the community so that their opinions are based on knowledge and understanding instead of hearsay, rumor and vague generalities. The spoken word through daily personal contacts, radio and television appearances, speaking engagements and social activities has its effect upon the relations of his organization with the community and general public. Every time the young engineer talks to a client, an employee, or a citizen of the community, an impression is made. It is important that these impressions be good.

A mature professional engineer with balance, perspective, and common sense, is not developed in a day or in a year. It requires living and working with people on the job and of the community. Most of all, it requires an attitude of "do unto others as you would have them do unto you."

A TEST FOR WRITING APTITUDE

And Improvement of Scientific-Technical Communication

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The need for a writing aptitude test became obvious to me when I discovered that most people cannot write. I am not talking about grammar or spelling; I am talking about the ability to record information in such a manner that others can understand and absorb it with a minimum of effort. I discovered, to quote Jacques Barzun, that simple English is no one's mother tongue—it has to be worked for.

Moreover, some people are more willing to work for it than others; and the same amount of work will make a good writer out of one person but will do very little for another. It occurred to me that writing might therefore require a special aptitude, in addition to intelligence, education, and professional competence. I realized that, if we could measure this aptitude and thus identify the people who could easily learn to write and would enjoy writing, we might get a step closer toward solving the communication problems that bedevil not only science and technology but our entire civilization.

What Problems?

What are these problems and how do they affect science and technology? Robert Maynard Hutchins summed them up last April in an address at San Diego. He said: "Nowadays, when professors meet, all they talk about is the weather—if they go beyond that they cease to understand each other." Scientific and technical literature is becoming more and more unmanageable. Its ever-increasin volume, the language in which mo of it is written, and the means b which it is disseminated are begi ning to defeat the purpose of th process.

To keep informed about progress i all the sciences has become almost im possible. The various scientific disc plines have practically lost conta with each other. Most workers ca not keep up with the progress with their own discipline and find it mo and more difficult to follow eve the developments in their particul branch or specialty; the specialists a beginning to complain that they fa to understand their own colleague

Even the psychologists are ap proaching this impasse, as evidence by an address of Bertrand Klass of th Stanford Research Institute during panel discussion on "The Problems Interdisciplinary Research" at a mee ing of the American Psychologic Association.

In parallel, a recent survey by Boo Allen and Hamilton of the researc and development work in 23 indu trial laboratories had a startling re sult: among 3500 professional peopl questioned, 40 per cent named poo communication as a major problem; was blamed for lack of success thre times as often as inadequate salaries

The Causes

Some of the causes for our com munications problems were mentioned in another context, by William Sloane Director of the Rutgers Universit

Press. One is the flood of unnecessary publications:

". . . the academic scholar in many fields virtually has to publish to secure preferment. The result is another book, and another. Often and often these are not books aimed at the reader, but at a special aspect of the professor's own subject. . . ."

Another cause is excessive bulk:

"What might well have been a useful monograph becomes a book padded and extended by bolstering evidence. . . . Through this the reader has to snowshoe his way to come on what the author really has to say."

And a third cause is lack of writing aptitude:

"The percentage of professors who have mastered the intricate craft of writing is probably higher than that of men in any other profession. But it is still a small percentage. . . ."

Another competent critic, Dr. Paul R. Hawley, Director of the American College of Surgeons, was even more outspoken.

"That professional reputation is so influenced by the production of so-called scientific papers induces too many medical men to rush into print with a sorry dish of warmed-over tripe. . . . I think it would be a reasonable assumption," he wrote, "that ninety per cent of the medical literature of today could be dispensed with; and that this would increase, rather than diminish, the dissemination of medical knowledge."

Dr. Hawley then quotes John Finley, one-time Commissioner of Education of the State of New York, who once remarked:

"There are three classes of men who do not tell the truth except by accident: those who do not know it, those who wish to conceal it, and those who do not know how to express it."

While the difficulty of communicating and the compulsion to write and read unnecessary literature impair the efficiency and productivity of working scientists, the dilemma between research and teaching affects the training of future scientists also. The problem is old but far from approaching a solution. Walter R. Carmody wrote about his scientific training in a letter to the *Chemical and Engineering News:*

". . . I had instructors who were almost all mediocre teachers or worse. Under other circumstances some could have been good teachers, but their preoccupation with research left them little time

Typical Questions

1) Do you believe language is: a) a fascinating thing to play with? b) a tool for expressing thoughts and feelings? c) a means to win friends and influence people?

2) Do you believe a poet writes: a) to convey ideas? b) to express emotions? c) to amuse himself?

3) When you hear a speaker using rare words and complicated sentences, does it: a) amuse you? b) bore you? c) impress you?

4) After talking to a stranger who made a strong impression upon you, do you remember best: a) how he looked? b) how he behaved? c) what he said?

5) When you read a book you really like, do you: a) get completely absorbed in the story or in the author's ideas? b) keep a detached and critical attitude? c) admire and envy the author's skill?

for, or inclination toward, teaching; their days were spent at a level of intellectual activity far removed from the classroom, and they were poorly prepared to understand the problems or to satisfy the needs of most of their undergraduate students."

I believe the key word in this quotation is "inclination," but it should be "aptitude." We should not blame the man for falling down on his job, but ourselves for expecting him to do a job which he neither likes nor can do well. When the explosive development of our industrial society called for more and more scientists and teachers, we failed to realize that the aptitudes for research and teaching do not necessarily go together, and that the aptitude for writing is different from both. We continue to expect our scientists to teach, our college teachers to do research, and both of them to publish.

The result is that gifted scientists, who lack teaching aptitude, bore or confuse their students; that inspiring teachers, who lack the creative urge for research, publish a flood of irrelevant information; and that large sections of both, lacking the aptitude for clear and readable writing, produce scientific literature which is indigestible. If we want to improve communication we shall have to divorce research, teaching, and writing. People who can perform two of these functions are rare and people who can perform all three are exceptional.

Personality Placement

This is not a matter of training or skill, but primarily a matter of personality. Whether the personality traits involved are inherent, or implanted by early environment or education, is beside the point; it seems that they cannot be easily acquired or changed after maturity. Essentially, scientists are doers or creators, teachers and writers are re-creative interpreters. The difference is similar to that between composer and musician or between playwright and actor.

The difference between teachers and writers is no less profound, although both verbalize their ideas. They differ particularly in their attitude toward people. The ideal teacher has a direct, intimate contact with people and is stimulated by an audience. Psychologically he is closer to an actor or preacher than to a scientist or writer. The ideal writer, on the other hand, is primarily concerned with ideas and language. He lacks direct contact with people and is intimidated by an audience. He is almost by definition a poor speaker. The problem, then, is to develop quantitative methods for sorting out researchers, teachers, and writers, and an aptitude test may be the first step toward its solution.

The Test

The test consists of 63 questions, each with three alternative answers. These queries probe the opinions, attitudes, judgments and habits which I consider indicative of a person's aptitude for writing. Ten questions investigate interest in language and verbalization; 31 investigate attitudes and judgments with regard to words, language, writing, and the values attributed to verbal expression; 21 examine habits in the area of writing, reading, and speaking; and 13 examine success in logical thinking and coherent expression.

None of these questions measures skill or experience in writing. This is not a test for writers but for potential writers. Only question 64, which was added as an afterthought, measures experience in reading, writing, or editing by testing the degree of discrimination in the meaning and usage of words. And I am the first to admi

that the test is not perfect, although an eminent psychologist has stated:

"I have gone over the test items very carefully and to my knowledge they seem to tap all the areas which I would consider to be relevant to one's interest in and capacity for writing."

The decisive question is, however, how the test works in practice. Does it discriminate between writers and non-writers? Does it give consistent results with different groups of people under different circumstances? Have the predictions made on the basis of test scores turned out to be correct? I would say that the results are encouraging.

So far I have tested only about 300 people, and have not had an opportunity to apply the test to a large sample of the general population, or to calibrate it against a group of writers whose aptitude is beyond question. But I have tested several groups of technical writers, engineers and scientists, and technical artists, illustrators, and photographers, and the results have been amazingly consistent. Before presenting the test scores, however, I have to explain what they mean. The maximum possible score is 100; actually the highest score so far recorded was 86 and the lowest was 20. I consider scores between 45 and 54 as average and those above 54 as high. These limits are not entirely arbitrary. More than 40 per cent of all the people tested scored in the narrow range between 45 and 54; in the three top groups of writers, on the other hand, no individual scored below 45.

Results

The following table summarizes the results from all the groups tested to date. These groups are divided roughly into technical writers, scientists and engineers, and other technical personnel, including illustrators, photographers, and office personnel.

TABLE I

DISTRIBUTION OF OCCUPATIONS

Number in Group	Occupation	Per Cent Who Scored		
		Below 45	45–54	Above 54
	Technical Writers:			
18	Volunteers across U.S.A.	0	22	78
16	U. S. Naval Ordnance Test Station	0	44	56
8	Hycon Mfg. Co.	0	50	50
13	Ethyl Corp. (incl. Secy. & Libr.)	23	23	54
26	Adult Class in Creative Writing	35	35	30
39	Technical Publishing Society	25	50	25
8	Northrop Aircraft, Inc.	63	25	12
	Engineers, Scientists & Management:			
33	Technical Publishing Society	54	28	18
25	Naval Ordnance Test Station	56	26	18
17	Same, Jr. Professional Assts.	59	29	12
23	Northrop Aircraft, Inc.	56	35	9
	Other Tech. Personnel:			
9	Ill. & Photog., Hycon Mfg. Co.	23	44	33
8	Sec. & Libr., Naval Ord. Test Sta.	25	63	12
20	Artists, Northrop Aircraft, Inc.	30	60	10
34	Artists, Tech. Publ. Soc.	36	64	0

The division was made according to the stated occupation of the person tested, but this was in some cases misleading.

The scores of a group of technical writers at Northrop Aircraft, Inc., for instance, had practically the same distribution as those of several groups of scientists and engineers; upon further investigation it turned out that most of these men had been engineers or fliers and had been transferred to writing by administrative fiat.

The composition of each group is far from homogenous. Some of them represent more or less incomplete samples of the employees of a particular company; others are random samples of the membership of the Technical Publishing Society; one is an adult class in creative writing; and the group at the top of the table consists of people who wrote in from all over the United States after the first public announcement of my test and volunteered as guinea pigs.

The first vertical row of figures indicates the number of people in each group. The other three rows show what percentage in each group scored low, average, and high, respectively. The most striking feature of the table is the consistency of distribution for the scores. In each of the top three groups of writers, at least 50 per cent scored high and none scored low.

The next two groups show an increasing admixture of people who are actually engineers but somehow happened to land in a writing job; and the last group, the writers at Northrop Aircraft, Inc., previously mentioned, actually belongs among the scientists and engineers. The scores of the adult writing class, on the other hand, had almost a random distribution, indicating that the desire to write is not by itself a determining factor.

The distribution in all the groups of scientists and engineers, wherever they work and whatever their age and experience, was almost identical; in every group more than 50 per cent scored low and less than 20 per cent scored high. The scores of the various groups of illustrators, photographers and office workers showed a characteristic distribution, too, with a heavy concentration on the average level.

Interpretation

What does all this prove? Strictly speaking it proves only that the test measures fairly accurately and consistently certain personality characteristics which distinguish people in different occupations. That these personality characteristics actually determine writing aptitude could be proven only in two ways: either the test would have to be applied to a group of writers whose aptitude has been established beyond any doubt, and so far I have been unable to find such a group; or the test would have to be applied to a group of trainees at the beginning of a writing course, and their proficiency at the end of the course would have to be objectively measured by some other means.

The fact remains, however, that so far the scores of writers have been consistently higher than those of non-writers, and I feel reasonably safe, therefore, in predicting that anyone who scores high can become a good writer, provided he knows his subject. This does not mean that some of those making low scores could not with effort learn to write equally well or better; it only means that this is less probable.

Let me speculate for a moment on the potential uses for such a test. More and more industries are clamoring for technical writers. Since only a few colleges are offering courses in technical writing, the supply is far short of the demand and employers have only the alternative of pirating

or training. Training on a hit-or-miss basis is costly, but a reliable test for selecting suitable trainees would make it much more economical.

There is an ample reservoir of potential writers, because apparently one in every six scientists and engineers can become a good writer. Properly distributed in laboratories and plants, these writing scientists and engineers could produce all the necessary literature. The others, who do the work, would be relieved of the obnoxious chore of writing, but would of course sign as authors. In many cases this would not differ greatly from present practice, except that today the one who does the actual writing is rarely selected for his writing aptitude and his special training in communication.

A similar selection could be made among graduate students doing research at universities. Even some of the professors might profit by letting talented students write their publications. We shall then have to get rid of the term "ghostwriter," or at least of its opprobrious connotations. It should be no more disgraceful to have one's publications phrased by a writer than to have them illustrated by an artist.

The next step would be to end the practice of measuring a man's professional standing by the number and volume of his publications. When prestige publications are eliminated and the remainder, purged of unnecessary verbiage, are clear and readable, we shall have taken a major step toward the solution of the communication problem.

Wide Use

To be fully effective, however, the test would have to be used systematically at high schools and colleges. The students who qualify should receive special training and should be guided into professions where communication in writing is particularly important. I hope that increasing numbers of them will become professional writers.

We shall not have to offer them special incentives, for the ability to write provides its own satisfactions, but we shall have to accord them the same prestige and pay as other professional workers. Once we have enough professional writers in science, industry, and government, who report and explain ideas, facts, and policies, we might begin to understand each other again.

Looking farther into the future, I believe that tests for research and teaching aptitude will be perfected and these two professions will also be divorced. I can see no reason why a brilliant research man should waste his time on lectures which bore him because they are too elementary and bore his students because they are unintelligible or too difficult; I do not see why an inspiring teacher should have to do research work, if he lacks the necessary curiosity and imagination. While separating these two functions in principle, however, we should encourage by all means the scientists who are also inspiring teachers or lucid writers, and particularly the rare individuals who excel broadly in research, teaching, and writing.

This sounds like a call for more specialization, but it might have just the opposite effect. Dedicated science teachers who don't have to publish would produce more and better-trained science graduates. Researchers who don't have to teach and write would have more time to read. Fewer and shorter publications, better organized and written, would facilitate the flow of information not only within but also across the confines of the

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A SUGGESTED PROGRAM TO IMPROVE SCIENCE TEACHING

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In the physical sciences INERTIA is defined as "the property of matter by which it will remain at rest or in uniform motion in the same straight line or direction unless acted upon by some external force." Unfortunately this definition for inert matter is often applicable to people. In a prosperous democracy this resistance to change may result in complacency until a war or other events stimulate an awakening.

This type of inertia affects government, the armed services, education, and other activities. In the business world opponents to change are soon by-passed, but in too many cases champions of change in other fields are ignored until necessity demands a hearing. The Russian earth satellites made a dramatic impression on the minds of public and press and many are now urging a reappraisal of our curricula in science and engineering.

Regardless of the fact that education, like government, is partly a citizen responsibility, it is only natural for parents to leave the matter of education to the educators (in fact, the latter insist upon it, especially at the public school levels). If the public suddenly decides that the educational or governmental programs are not all that could be desired, it is quick to condemn both educators and government officials for any deficiencies.

A review of the record will show that many progressive minded educators and scientists have made suggestions in years past which might have resulted in a better educational program today, but the majority of our population was not in a mood to listen. For example, Dr. J. R. Killian, Jr. in 1954 made some valuable prophetic suggestions concerning our program in science and engineering (as reported in an article by James Reston, *N. Y. Times*—November 24, 1957) but no action was taken, perhaps because there was no public response. In a democracy the opinion of the people has a great influence on achievement; apparently the public is now stimulated and educators are at once expected to make suggestions for a progressive program.

High School

Many years ago, before industry and government developed a need for scientists in large numbers, high schools generally required such subjects as physics, chemistry, mathematics, and biology. When the "life-adjustment" theory of education came into vogue there was less demand for these subjects by the students for a very simple reason—sciences were difficult to learn. This once desirable freedom for students to select their own subject matter is now in many cases one sided. A student who desires to study serious subjects is denied this privilege because many courses are not offered for lack of demand, or, if offered, may be taught by a person who has no enthusiasm for the sub-

ject. This may turn the student against scientific courses.

Coaches of athletic teams and commanding officers of the armed forces maintain strict training rule for young men. These physical gymnastics are necessary to develop physical stamina for severe competition or combat tests. Physical education programs are now required subjects in practically all secondary schools (and colleges), but it has been easy to forget that we live in an age when well trained minds are also necessary. The "mind-in-training" must exercise more brain cells for longer periods in a way comparable to the muscular exercise of athletes. Not every individual can become a great athlete or a great scientist or engineer, but if properly taught by competent instructors the training is generally beneficial to students.

However, we cannot afford to be panicked into adopting a program of requiring scientific subjects to the point of excluding everything else. This is too high a totalitarian, self-destructive price for national security. If, however, the people of the United States will provide the facilities to offer scientific (and engineering) courses to all qualified young people at all levels of high school (and college), then the educators are obligated to use their best efforts in advancing the content and approach of those courses.

Newspapers (including comic strips), television and radio will undoubtedly stimulate more interest in scientific subjects. Additional effort and expense will be involved in selecting those students who can derive the greatest benefit from scientific training, but the final results should justify public approval of the program.

Texts

A Physical Science Study Committee at the Massachusetts Institute of Technology under a grant from the National Science Foundation, with the cooperation of teams at other institutions, has been developing a new secondary school textbook in physics, one ". . . appropriate to the subject in the middle of the twentieth century. . . ." Besides a steering committee of seventeen members, the book has 121 contributors. The preface to the preliminary volume (one of four planned) states, "The physics course, for which this book is the text, depends on more than this book."

The committee is also developing economical laboratory equipment for some excellent experiments. If succeeding volumes are on a par with Volume I, the text should stimulate both teachers and students in physics. The progressive approach to the subject was initiated by the authors several years ago (without regard for Sputnik) and should now receive encouragement and acceleration.

More than five years ago a committee at the University of Illinois began intensive work on the development of a new text (or texts) in mathematics. Dr. Max. W. Beberman later secured a grant from the Guggenheim Foundation for extending the activity of the group. Material is distributed to high schools and universities over the United States. Some high schools have indicated an interest, but the texts deserve wide adoption. Other groups of progressive individuals have attempted to upgrade the effectiveness of mathematics and science teaching but in many cases they have found the inertia of the "system" too great for appreciable change.

Federal Aid

Since the people may now be in a mood to bear the costs of better education in science subjects, the matter of Federal Aid must also be faced.

Progressive minded states and communities will surely take positive action on their own initiative without waiting for federal aid. The issue of federal aid to education may not be resolved for some time, and further delay in our program must be avoided if possible.

For many years the Federal Government has extended financial aid to secondary schools (under the Smith-Hughes Act) for teachers of vocational subjects in agriculture, electricity, plumbing, auto-mechanics, machine shop, welding, sheet metal work, beauty operator training, special mathematics courses, home economics and other subjects. Many large cities have vocational and technical high schools. Federal salary aid is available provided teachers of the above subjects posses special qualifications and in most cases the total compensation for these staff members exceeds that of teachers in other subjects.

This established precedent might be followed in salary aid for teachers of high level courses in mathematics, physics, chemistry and others. If the people really desire such an act, it can surely be approveed without delay. The aid should retard, or even reverse, the flow of science teachers to positions in industry. This program should be endorsed by the vocational education division of the States as it would presumably be administered by State offices. The plan should probably have a time limit to encourage self-support at the state and local levels.

The National Science Foundation has granted funds to a large number of colleges and universities to enable high school teachers of science and mathematics courses to study teaching methods and subject matter for one year. This might be termed a program to qualify teachers in these subjects "appropriate to the middle of the twentieth century." The program is commendable and should be expanded. There are other programs to improve our high school instruction of scientific subjects, some sponsored by industry; all should be expanded greatly and quickly.

The above programs might well be used as a pattern to improve teaching for staff members of engineering colleges. It would surely be endorsed and encouraged by the American Society for Engineering Education and the Education Committees of the professional organization in the various branches of engineering.

Last September the National Science Foundation and some large manufacturing companies sponsored for colleges an Electrical Engineering Curriculum Workshop at the Massachusetts Institute of Technology. Approximately 110 Electrical Engineering Departments were represented. The object was to discuss new developments in the field and methods of teaching special topics. Many of those who attended are prominently active in ASEE, AIEE and IRE. The group was almost unanimous in praising the success of the Workshop and many letters to the Foundation urged that it be repeated periodically. These recommendations do not mean that the Workshop should replace any of the excellent work being done by ASEE, AIEE, IRE or others, but it can be a valuable supplement. This form of Federal Aid should be expanded.

In recent years many engineering graduates are finding that they should continue their education. Universities, colleges and industry are cooperating in the establishment of graduate courses leading to the M.S. degree. These extension (or continuing education) courses are beneficial and the demand for them will probably increase. More fellowships should be made available for outstanding young

engineers, especially those who may desire to leave industry for a career in teaching.

U. N. University

In May, 1951, the author suggested to his senator, his congressman, and the Ford Foundation the possibility of a United Nations University. The suggested curriculum would include all sciences (including social) and government. A primary objective would be an exchange of knowledge concerning the philosophy and culture of people from other countries. Students would spend at least a year or more in different countries. Mental stimulation should result from a friendly rivalry in the creation of new ideas and solutions to problems while working in a peaceful atmosphere.

Senator Homer Ferguson forwarded this letter to Warren R. Austin (U. S. Representative to the United Nations) who expressed interest in the plan and requested more details. However, an extensive study would be necessary to develop a complete plan and to decide such questions as the selection and rotation of faculty members and whether or not a baccalaureate degree should be required for admission. The Ford Foundation was not in a position to extend favorable consideration at the time and apparently the idea has been dropped. Surely a university of this type would receive support from the free nations and, if the Russians refused to participate, could function efficiently and happily without them.

Summary

Many articles are written on the present deficiencies of our education system. The public may ask why we have failed to do something before now. One answer is that many have tried for years to arouse interest in promoting better scientific and engineering educaiton, but very few listened except those in our own group. Many papers have been given on the subject and it might be a good plan to review these if the public is ready to listen. Regardless of the fact that public attacks have fallen on deaf ears for years, the onus is on us as educators in science and engineering to furnish leadership. We will be at fault and will be blamed if the deficiencies in our planning result in disaster, or near disaster.

The U. S. has not reached its present position by pursuing a policy of copying other nations, so let's continue to do our own thinking. No new plans in education that we initiate today can show results in the near future but this should not create apprehension or panic. We cannot afford the folly of attempting a completely new educational system. We should make a thorough reappraisal of our present system and make mature decisions on retaining the desirable elements. Improvements should be coordinated on a broad and continuing basis. Teamwork with all the existing educators, educational organizations and committees can create beneficial results for the present and future generations.

PEDAGOGICAL ENGINEERS

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The purpose of this paper is to state and briefly defend the thesis that the system of engineering education in this country would profit if a small fraction of its educators had some special background in education, specifically, engineering education. It is not here contended that the system of engineering education needs such people for its existence or continued survival, but rather that such men could make valuable contributions to the vitality of the system. The question is therefore not a matter of life or death for the system, but a matter of improving its state of health.

The climate of opinion today in many segments of our society is highly critical of "educationists" and of special study in education. In view of this, perhaps it would seem to be a particularly inappropriate time to suggest to engineering educators that their system would profit if some of their number had a special background in education.

Nevertheless, the author feels that the contributions which such people could make to engineering education are sorely needed now, and that the need will grow more severe with the passage of time. Furthermore, the author feels that the proposition advanced herein, when fully understood, is a reasonable one and that a consideration of its validity will not be seriously jeopardized by current opinions regarding "educationists."

Because all teachers in elementary and secondary education are required to take education courses for certification, it is usually asumed that any reference to a "background in education" concerns itself with courses designed to improve a teacher's effectiveness. This notion will serve as a good point at which to begin the discussion even though, as will develop later, it is somewhat peripheral to the principal idea in this paper.

Extreme Attitudes

It would seem that the views on education courses held by members of our society are distributed along a continuum between two extreme attitudes: (a) that education courses should be compulsory for all teachers, and (b) that education courses are worthless, of value to no one. The first position tends to be taken by those who hold either: (a) that a teacher cannot be a good teacher without such courses, or (b) that while a teacher might be a good teacher without education courses, he would *necessarily* be a better teacher if he took them. The other extreme would tend to be accepted by those who maintain either: (a) that education courses are *inherently* worthless, perhaps even harmful, or (b) that while such courses might theoretically have some value, as they currently exist, they are worthless.

In the opinion of this writer, both extreme positions are untenable, for whatever reason they are held. There are of course many intermediate viewpoints. Because it is not closely connected with the main theme of this paper, no attempt will be made herein either to refute the extreme views

mentioned above, or to defend the intermediate views of the author, which, regarding engineering teachers, are as follows.

Many teachers can be quite successful, even outstanding, without the experience of education courses. There are, however, others who would probably derive considerable benefit therefrom, either because their natural aptitude needs development through study and directed practice, or because they are placed in a very challenging teaching assignment requiring more than the usual amount of insight into the processes of human learning and motivation.

For such people, well-designed and well-taught education courses should be *available* because, while it is certainly true that teaching is predominantly an art (learned therefore through experience), it is equally true that there is value in giving teachers the opportunity to imbibe the distilled experience of many generations of teachers and to reap also the fruit of countless hours of psychological research into the processes of human learning.

Voluntary Study

Note that it was stated above that such courses should be "available," and by this the author wishes to convey his opinion that such courses should never be compulsory, but always *elective*. A person derives little benefit from a course in which he has no interest; the presence of "involuntary" students in a course almost inevitably reduces the quality of learning for those who are sincerely interested in the course content.

Furthermore, the author would be inclined to recommend that no academic credit be given for such courses. This would be on the principle that if such a course is of any real value, the compensation for successful completion would come through increased effectiveness as a teacher. This should lead to increased professional recognition as a teacher, with the eventual tangible rewards of increased rank and salary.

At present, however, with teaching effectiveness so very difficult to measure, such increased effectiveness, of and by itself, might be of less professional value than a transcript of credits. Hence, as a matter of expediency, graduate credit might be permitted.

Finally, the author would like to state his opinion that far too few engineering schools have any courses or seminars of this sort available for their staffs. This would seem to be a particularly appropriate activity for schools which are aware that they have some responsibility for the professional development of their staffs *as teachers*.

So, in the opinion of the writer, the system of engineering education would benefit if there were available in more places well-designed and well-taught education courses for teachers who wished to attempt to improve the quality of their teaching by such means. But, as stated earlier, the author feels that there is another, and in some respects more important, way in which a special background in education would enable people to make a unique contribution to engineering education.

Educational Leaders

When a young man begins to teach engineering, his sphere of influence hardly goes beyond the boundaries formed by his classroom walls. While his influence upon the lives of his students may be remarkable, his influence upon the system of education of which he is a part is necessarily, and properly, quite small and indirect.

Yet, from the large number of men

who, in a given decade or span of years, begin to teach engineering, there gradually emerge the future leaders of enginering education. It is with these future leaders and with their preparation for their complex and ever-growing responsibilities that this paper is principally concerned.

Shall the acquisition of the knowledge and experience which would be most helpful to these leaders be left almost wholly to chance? Is it not possible that, by giving thought, the system of engineering education could analyze the multi-dimensional responsibilities of its leaders? It could then decide what background (over and above teaching experience) would be valuable, and could provide means whereby such additional background could be thoroughly and efficiently gained by those who give clear promise of growing to leadership in the field to engineering education.

Relations to Society

Engineering education, no different from any other form of education, is a dynamic system, it is in a process of continual interaction with many other components in our society. Not only do trends in industry and in secondary education have a marked influence on engineering education, but the economic status of the nation, the temperature of the international cold war, new developments in basic science, the growth of professional consciousness among engineers, all these and many more have their effects upon engineering education.

Above all, society influences engineering education through those complicated (and alternately bewildering and fascinating) creatures, known as students, whose education is our challenge. These youths bear all the marks (some would say scars) of the society whose product they are. They bring from that society, among other things, a complex network of drives and tensions into which is woven a set of preconceived (and frequently erroneous) notions regarding the nature of engineering and the manner in which engineering students should be educated.

In reciprocal fashion, engineering education influences society. Engineering education has responsibilities of which it must be cognizant and which it must be prepared to shoulder; responsibilities to the individual students, to the profession, to other parts of the educational system of the nation, to industry, and to society. Engineering education, as already stated, is a dynamic and changing system; as such, it has a history and a future.

There are problems which it faces today which can be intelligently grasped only in terms of their long historical roots, and these only when placed within the context of the evolution of the entire system of engineering education in this country. Furthermore, the problems of tomorrow are being generated today, so their nature and severity could to a degree be foreseen and forestalled, with the help of those who have deep insight into the complexity of the total system and its many interrelationships.

Engineers versus Technicians

It is in response to internal pressures and external forces that the system is constantly changing. But, the system is not some inanimate object, responding in accordance with fixed laws. Insofar as it changes, it does so because prominent men bring their influence to bear. Therefore, whether the changes are for good or ill is in a large measure determined by the capabilities of these influential leaders, by the extent to which they have fully understood the problems and the total range of possible solutions.

Now there may conceivably have

been a time when engineering education and all the components of society with which it interacted were simple enough so that no special thought had to be given to equipping leaders to perform their tasks. It is the opinion of this writer that today, while it may still not be absolutely necessary that future leaders be given special training for their challenging and complex roles in engineering education, at the very least it would be helpful if some of them had such background, which was termed above a "special background in education, specifically, engineering education."

Shall our system of engineering education be redesigned by men equipped with only a few rule-of-thumb "pedagogical formulae" and a limited base of personal experience? Will they operate like so many technicians (armed with a few empirical relationships and some specialized experience) trying to "redesign" by cut-and-try some complex engineering device?

Or shall we have instead men who, through careful study and training, have gained a thorough knowledge of the entire system, its history, objectives, methods, challenges, and weaknesses? Such men would not be "pedagogical technicians" but "pedagogical engineers." They would be able to refashion our educational system in terms of underlying principles rather than by a few superficial empirical relationships; in terms of a broad background of knowledge rather than a narrow base of personal experience. They would be capable of producing entirely new solutions rather than being restricted to trial-and-error extrapolation of existing solutions.

Summer Schools?

The idea of a Summer School for Young Engineering Teachers has been kicking around in ASEE for more than two years. There has been considerable discussion regarding the purpose, nature, and duration of such a summer school. It is the opinion of this writer that it should not be, as some have suggested, a session devoted to teaching methods and techniques, to psychology of education and the like.

This is not to imply that a "teaching methods seminar" would not be valuable, for it certainly would, especially to many beginning teachers. But, as discussed at the beginning of this paper, such an aid to good teaching would probably best be handled at the local level, for it would seem that it is there that such a responsibility rests.

Rather, if there is to be a Summer School for Young Engineering Teachers sponsored by ASEE, let it be for a type of training which is hardly an institutional responsibility, that is, the training of a select group of young men who, after ten or more years of devoted service to engineering education, can be singled out by their superiors as giving promise of being able to go on to assume ever-increasing responsibilities.

Let such men be given repeated and varied opportunities to become intimately familiar with all facets of engineering education. Remove them from the hustle-bustle of the academic treadmill, place them in a fertile intellectual atmosphere where, acting as catalysts upon each other, they will be stimulated to discard their special blinders and gaze objectively upon the entire system of engineering education in this country.

They should be encouraged to study its past, evaluate its present state, and chart its future; to ask probing questions and demand straight answers; to knife through the layers of platitudes and generalities and lay bare the essence of the system and its problems. Such are the men, "peda-

gogical engineers," to whom the future evolution of engineering education could most safely be entrusted.

And so, to return to the opening paragraph, the writer contends that engineering education in this country would profit considerably if some of its members were possessed of a special background in education, specifically in engineering education, as described above. Perhaps the day will soon come when some school, whose officials have great foresight and imagination, will establish a systematic program for the development of potential leaders in engineering education, thereby performing a service for which the whole field of engineering education and all of society would be forever grateful.

SANITARY ENGINEERING STUDY

A report has recently been published on the Conference on Education, Training and Utilization of Sanitary Engineers, held in Washington under the auspices of the Subcommittee on Personnel and Training of the Committee on Sanitary Engineering and Environment of the National Academy of Sciences, National Research Council.

This report constitutes a significant, comprehensive analysis of the sanitary engineering profession, with specific reference to career opportunities and recommendations on recruitment and educational objectives. Copies are available upon request made to Thomas R. Camp, Chairman, Joint Committee for the Advancement of Sanitary Engineering, 33 West 39th Street, New York. The committee represents ASCE, AICE, ASEE, APHA, AWWA, and FSIWA.

INSTITUTE PLANS WIDESPREAD TRANSLATION OF SOVIET RESEARCH

A nonprofit foundation, the Pergamon Institute, is initiating a large-scale program for the translation of Russian books, journals, and research papers in critical fields of science, technology, and medicine. Its stated aims are to make available, to English-speaking scientists, doctors, and engineers in the United Nations countries, the results of the accelerated research and development taking place in the Soviet orbit. The Institute now publishes selected journals in translation, as well as lists of the contents of current Soviet publications. A Pergamon symposium scheduled for the summer of 1958 will discuss the promotion of Russian-language studies in the universities of the English-speaking world. Information can be obtained from I. R. Maxwell, Executive Director, 122 East 55th Street, New York 22, N. Y.

OUR HIDDEN ENGINEERING SUPPLY

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The American disasters in the satellite field have impelled us to ask searching questions about our abilities in all technical fields; and the answer to these questions has been pretty unanimous. America has fallen behind Russia in the output of technically trained people at all levels, and the results of this lag are showing up.

These remarks apply equally well to all skills brought to bear on the problem of producing new ideas, new techniques, and new machines. At the scientific level, we have slipped badly, not so much in the quantity of graduates as in the quality of their training. As a result, it takes several more years for our college graduates to learn their profession to the standards required by the Russians. To remedy this, we must reform our educational system on the basis of earlier and more rigorous education and training for bright students.

At the engineering level, the problem is even more acute and more complex. We actually turn out more college-graduate engineers than the Russians. For a few who are most creative, we give challenging opportunities requiring just about the same skills as the sciences, and subject to the same limitations in our educational system. But most of our best graduates end up in jobs which barely demand the skills they have learned.

Where the Russians have us beaten nine ways to the middle is at secondary school level of education. Their engineering high schools turn out millions of people each year whose engineering training is as good as is required for most of our engineering jobs. Where we staff these jobs with the bottom half of engineering schools, they staff them, more numerously and more efficiently, by drawing on the cream of the artisan labor force. Hence, it is to this group that America must turn to meet the real challenge.

We cannot afford, now especially, to tolerate any downgrading of abilities either by education or by job opportunities; my own experience has been that the best mechanics, machinists, electricians, carpenters, and draftsmen are essentially engineers whose full talents have not been realized. I might suggest remedies. Accelerated early education, so that vocational schools could incorporate the required science, math and engineering in their programs, would enable our high school graduates to compete successfully with their Russian counterparts.

Further, evening and extension courses in our universities would be formalized to lead to a professional certificate, and made more demanding to make such certification meaningful. Most important, the labor union movement must provide initiative and recognition of the merits of upgrading its membership to meet the rigorous standards of international competition.

To summarize: we need an accelerated and rigorous early education for young people who have any talents above the average—to provide better trained scientists and research engineers—to provide more opportunity for training at the junior engineering and skilled technician level. In these grades, our greatest reservoir is the labor movement, and it is its responsibility to suggest and advocate new techniques for educating its best people for the challenges ahead.

EDUCATION OF SANITARY ENGINEERS: AN APPRAISAL

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The opinions expressed are those of the author; The Chlorine Institute and its members, jointly or severally, assume no responsibility for any statements made.

Post-war accelerated technology has opened vast new areas to sanitary engineers, enlarging the foundations upon which their careers are developed. The extent to which a novice sanitary engineer can accept the challenges accompanying this Nation's industrial growth depends largely on the intellectual stimulation and motivation he receives in college.

In the ultimate analysis, of course, no single element of the total can be claimed responsible for the mold of his professional development. The responsibility is shared by the student, his teachers, the profession, industry, government, and, indeed, by society in general.

This discussion is, therefore, limited to an appraisal of educational practices in terms of contemporary needs for advanced professional skills. No attempt is made to define the desirable or even minimum scope of sanitary engineering curricula.

The Sanitary Engineer's Role

At this point, it is necessary to sketch what is believed to represent the performance criteria for sanitary engineers, for these are what dictate the extent and character of his academic exposures, and thus the degree to which his requirements are fulfilled.

For the purpose of this discussion, professional sanitary engineers can be classified into two groups. The first includes those whose major interests might lie, for example, in administrative and managerial positions, procurement of technical personnel, operations control, sales, perhaps public relations. Such persons are interested primarily in the *applying* side of the profession. The second group is interested primarily in the *knowing* side, and might include those involved in fundamental research, process development, design, consulting, or teaching.

Admittedly, such a classification is arbitrary, and it might justly be argued that there is a continuous spectrum of development from the most abstract principle involved, for example, in research concerning the removal of radioactive materials from water, on to process design, construction, operation, maintenance, staffing, and supervision of the treatment facility. The point of emphasis is that sanitary engineering, like other engineering disciplines, involves various competencies and in varying degrees; what might be considered adequate for one may be totally inadequate for another.

In developing this thesis, it should be recognized that despite the level of man's technological sophistication, within a realistic frame of reference basic personal and environmental hygienic requirement will not be materially altered. Here the implication is

that constant vigilance of fundamental sanitation principles, as typified, for example, by the more routine activities of official health agencies, will continue to warrant attention by sanitary engineers and well-informed sanitarians.

Orientation and basic indoctrination in these principles appears to be obtainable to a reasonably satisfactory degree in the majority of present-day sanitary engineering curricula. Coupled with practical experience—to be obtained after graduation—this background appears to be adequate for the sanitary engineer whose career objectives are limited to this type of endeavor. These are important and responsible positions which always will have to be filled.

It is incorrect to conclude, however, that sanitary engineering embodies only limited opportunity for professional growth and development. It is a dynamic profession, one which obviously no longer is fully exemplified by the relatively simple *classical* fields of "water supply and treatment" and "sewerage and sewage treatment" prominently listed in university catalogues. Even these have been affected to such a degree that they are specialties in themselves. Indeed, one can specialize and devote his career energies to a single one of the many facets encompassed by either of these two.

That this should be so is perfectly natural; technological evolution does not follow the pattern *a,b,c,* but rather a, $a + b$, $a + b + c$, and so on; each new technological advance—and these have no sharp boundaries—tends to merge into the previous one, retaining some of the earlier problems and introducing added fresh ones. The degree of specialization implied here is not available nor will it (or should it) ever be available from a four-year engineering curriculum.

Fundamental Engineering Indicated

In consonance with the times, however, a gradual departure from the classical concepts of engineering fields recognized today—civil, mechanical, chemical and others—is as inevitable as it is essential. With the unusual complex of problems sparked by accelerated defense and industrial production, existing emphasis on the boundaries of different technical fields at the undergraduate level must be decreased. If engineers are to be successful and are to contribute something substantial toward elevation of their personal status as well as that of their profession, they must be equipped with a more extensive and thorough knowledge of basic engineering principles common to all engineering disciplines.

This can be accomplished only through modification of highly departmentalized curricula characteristic of many universities. While engineers whose interest and talents have been developed in a very specialized area will always be in demand, these can not realistically be cultivated through an undergraduate program. But there also is likely to be a continuing need for those with broader interests whose training, though limited, has been along these progressive lines.

Scope of Undergraduate Training

A review of the evolution of sanitary engineering training indicates that relatively little has been effected toward the development of undergraduate curricula (including options and electives) sufficiently comprehensive to enable the average graduate, without subsequent formal training, to achieve professional prominence in these times. In fact, a high degree of undergraduate specialization, leading to a bachelor's degree in sanitary engineering, would not appear to be to

the best interests of either the student sanitary engineer or to the profession.

This is true first, because the varied functions of a sanitary engineer necessitate education even more extensive than that ordinarily acquired through basic engineering training—for example, in biology, biochemistry, physiology, public health, and other subject areas. Obviously the amount of time that can be allotted to such specialized training for engineers without impairing basic engineering education is limited.

Second, if he is to fulfill his responsibilitiy to society, the engineer, must have been exposed to the social sciences and arts in addition to the basic engineering and scientific disciplines. The so-called "humanities" field also has an essential place in the education of sanitary engineers because of the nature of their professional operations and their ultimate impact on the whole of society. Proper emphasis, roughly about 20%, appears in general to have been given in recent years to such subject areas as an integral part of undergraduate engineering programs.

Thus it seems virtually impossible to crowd specialized sanitary engineering subjects into a four-year program. Accordingly, it can not be reasonably expected that the undergraduate student, with hardly more than a brief exposure to sanitary engineering, will be prepared after four years of college to embark immediately upon a productive professional career in sanitary engineering. This is particularly true, for example, of emerging facets of water resources conservation and pollution control, which require a very thorough understanding of a variety of engineering, scientific, and social disciplines.

What Employers Expect

Prospective employers of sanitary engineers do not expect that the engineer graduate will have been equipped in four years to be productive at maximum output immediately subsequent to the receipt of his degree. They do expect, however, that he will have developed self-reliance in learning and in the application of basic knowledge to professional problems. In other words, they expect that academic sights should be directed to the "long pull," so that students embarking on a professional career will be at ease in an era when new knowledge is being discovered at an unprecedented rate and problems of ever-increasing complexity are being encountered.

For this reason it is imperative that employers of sanitary engineers establish and maintain effective liaison with sanitary engineering educators, in order that educational programs can be promptly and efficiently reorganized or otherwise adapted to meet these needs. This represents a very serious weakness of the profession and one which, if it persists, will weaken its chances of achieving the professional and public recognition it merits.

Graduate Training Indicated

One effect of the increasing gap between sanitary engineering education and professional performance has been the clamoring by some for more and more time to prepare a potential professional for service in his elected specialty. An evaluation of the very controversial issue of the merits of a four versus five-year undergraduate program in sanitary engineering is outside the scope of this report. There presently is no evidence, however, to suggest that widespread adoption of a five-year undergraduate curriculum is imminent.

Logically, if preparation for those positions that require a high degree of creative ability cannot be obtained at the undergraduate level, graduate

training appears essential to the performance of genuinely-professional career services in highly specialized sanitary engineering areas. This can be effective and can assume proper value only if the lengthened academic program is devoted to advanced and specialized indoctrination in essential related disciplines,* with a firm background in engineering fundamentals being a prerequisite to admission for such training. Frequently, however, many "advanced course" offerings are simply overdressed versions of elementary, long-established principles that could easily be assimilated on a much lower academic plane. And too frequently they fail to prepare the student for today's—much less for tomorrow's—professional activity.

Educational Responsibilities Are Shared

Industry and government are beginning to recognize the seriousness of a shortage of sanitary engineers who have an educational background which equips them to cope with technological complexes typical of these times. In the State and local official health agencies, for example, of more than 30% of all sanitary engineers who have had at least one year of graduate training, over 90% have received such training at State expense.

At the Federal level, this pattern also is being established. In the field of water resources, for example, several of the Federal agencies concerned are providing additional formal training for a number of their engineers to improve their preparation for development and administration of water resources conservation and pollution abatement programs. Notable is the recently organized academic program developed by Harvard University and supported by a Rockefeller Foundation grant.

In the air pollution field, at Harvard, Massachusetts Institute of Technology, the Universities of California, Florida, and Cincinnati, and elsewhere, the Public Health Service has worked closely with sanitary engineering educators in pioneering academic programs suited to the peculiar needs and backgrounds of the engineers enrolled in these programs. This has necessitated a quite radical reorientation by foresighted sanitary engineering educators, involving a complete overhaul of classical sanitary engineering graduate curricula to fit individual needs.

Industry too—the giants of today and the giants of tomorrow—in addition to sponsoring formal education for promising engineers, has embarked on a program of intensive in-service training adapted to their own special needs. Like government, industry is willing to subsidize advanced training of their sanitary engineers, but only in those instances where the individual's earlier training has been along the progressive lines previously mentioned. Contemporary recruitment officers appear more concerned with a prospective employee's flexibility and the extent to which he has the potential for devising and answering originally-conceived questions than in artificial, robot intellectuality.

Presenting a mass of statistics on manpower resources has been deliberately avoided, for these in themselves are only relative in the light of this discussion. Obviously, many sanitary engineering graduates are lost to the profession by attrition and attraction to other fields. (Incidentally, sani-

* The term *discipline* is deliberately used in preference to subject matter, the associated connotation with the former being a way of thinking rather than the mere aggregation of facts. Basic disciplines, such as mathematics, physics, and chemistry, represent the *means* of intellectual achievement; others, such as statistical theory, radiophysics, biochemistry, and micrometeorology, are emerging needs in response to the alert engineer's motivation for intellectual distinction.

tary engineering educators share the responsibility of minimizing these losses.) And doubtless others will ultimately lapse into the role of technicians either through their own intellectual inadequacy, through short-sighted management that fails to permit employees to demonstrate their prowess, or through failure to recognize that education in today's competitive technology is a lifetime responsibility. Unless a sanitary engineer's education is continued, he will ultimately be a professional failure; and unless he has learned this in his collegiate years, his teachers also have failed in one of their most important responsibilities.

Summary

Higher education has lost considerable repute for failing, in many instances, to provide the intellectual capacities it purports to represent. Academic courses that teach one how to apply statistical formulae but ignore the theory and limitations of their usage, to conduct B. O. D. tests without an understanding of their true meaning, to summarize biological data without thinking critically—these fail hopelessly. The ultimate test of any curriculum is the extent to which it trains the student to think independently, to develop a penetrating mind that will elevate him above the technician and enable him to perform new and more difficult tasks. Educational processes should begin at the primary and expand through and beyond the post-graduate levels.

Of the effectiveness of contemporary sanitary engineering education, it can be said that undergraduate programs serve primarily as a valuable orientation in the opportunities and challenges of a sanitary engineering career. Little more is or should be expected than to cultivate the student's creative thought processes and his ability to communicate these effectively by providing a sound, integrated education in the basic engineering and scientific disciplines, coupled with instruction in the social and human sciences.

If such is the product of an undergraduate educational system, he will be flexible and versatile enough, able to specialize and to apply graduate-level knowledge with satisfaction and ease. And he will be capable of understanding and discussing with intelligence the ever-increasing common scientific disciplines upon which the solution of complex sanitary engineering problems depends.

AERONAUTICAL DIVISION MEETING

A joint session of the ASEE Aeronautical Division and the Institute of the Aeronautical Sciences will be held in the Ambassador Hotel, Los Angeles, California on Tuesday, July 8, 1958, as part of the IAS National Summer Meeting.

Dr. Samuel Herrick and his associates will present the problems that were met and solved in developing the Astronautics Curricula for the University of California, Los Angeles.

It is planned that the summer joint session program will follow the Aeronautical Division's joint sessions at the winter meeting of IAS as an annual affair.

GRAPHIC SCIENCE

Analysis—Synthesis—Communication

Sponsored by the Engineering Drawing Division
Editor: Eugene G. Paré, Washington State College, Pullman, Washington

IN QUEST OF ENGINEERING CREATIVENESS

C. G. A. ROSEN

ASME Lecturer, 1957
Woodside, California

It has been said there are no new ideas under the sun, but new concepts do appear from time to time and are made practical by the energy and enthusiasm and intestinal fortitude of the enterprising individual.

Today we have tremendous interest expressed in the gas turbine and jet engine. The original concept of the gas turbine was devised by Hero in the Second Century before Christ. Hero built the first gas turbine as a toy to entertain some Egyptian priest. It has taken from the Second Century B.C. until modern times, twenty-one hundred years, to develop the gas turbine to the point where it has promise in our future automotive equipment. It has been predicted that the gas turbine will find its way into some automotive equipment within five years. The years of delay, awaited the theoretical work of Prandtl in Germany and the discovery of vitalum as a high temperature material. An ancient idea fortified by new fundamental information, permitted utility by the discovery of new materials, and was made commercially possible by advanced fabricating techniques. This has given promise to revolutionize power propulsion methods.

It is now conceivable that atomic energy using gas turbines for driving armoured military equipment may be with us in fifteen years. It may be significant that the top men in automotive research are atomic scientists: Dr. Hofstad of General Motors Research, Dr. Kucher of the Ford Scientific Laboratories and Dr. Lewis of Chrysler's Basic Research Department.

This leads us to the subject of creative engineering. The needs of the future are tremendous, and vision to plan that future is a commodity of even greater significance to the engineer today than it has ever been in the past. It has recently been demonstrated that Russia is making rapid advances in engineering and science. Russia aims to make Moscow the scientific center of the world. In order to survive, we, as a nation, must be keenly alert to these facts.

How has Russia's progress been made possible? What is the impetus that has achieved this enviable position by the Soviets? Although they have less steel producing capacity than we have in America, they are not permitted to allocate steel for automobiles, ice boxes, TV sets, all the modern conveniences of our American way of life. All such steel quantities are diverted in high percentages to military uses. The Russians are allocating 25% more tonnage of steel for military uses than the United States.

This is also true of fuel. It is a comparatively simple matter for Russia to commandeer gasoline for military purposes as the Russian public is not accustomed to having gasoline available for automobiles. Heating with petroleum fuels for homes is unknown in Russia; therefore, gasoline and diesel fuels can be converted to the military economy. Our way of life is a handicap. We must, therefore, find ways and means wherein we can be more productive, more creative, in achieving newer and more advanced products, and provide such an advanced front of scientific engineering development that the Russians will never be able to catch up with us. This, however, places a premium demand for a greater supply of high quality scientific and engineering manpower.

The Russian engineers are dedicated to their profession. They worship at the shrine of their activity as though it were a religion—an enterprise of major significance to their life and living. Furthermore, engineers are given a status of dignity, a position of eminence and a commensurate salary. It is a high honor for a boy to be chosen for an engineering profession. Their scientists are near the top echelon of the social structure of Russia; our way of life diversifies our interests. Of great significance is the fact that the Russian system gives tremendous impetus to the uncovering of scientific fundamentals. For instance, the work of their astronomers has been outstanding. Children in primary grades are early brought to the knowledge of scientific and astronomical fundamentals.

The world today is tremendously active in achieving long range missiles, in accomplishing space flight through rockets, and in the development of celestial navigation. All of these scientific and engineering advances are predicated on increasing the scope and knowledge of astronomy. The control of an intercontinental missile or a rocket propelling a hydrogen bomb can only be effective in its ability to achieve its end purpose by maintaining its navigational course. This can only be accomplished by cancelling out the effects of radiation from the stars, deviating forces from meteors, cosmic and other rays which emanate from outer space.

We can all contribute in encouraging the romance of science in yet unexplored fields, by encouraging teenagers to look upon science and engineering as a great venture for their lives. This does not mean that we can sell the idea that every high school student should go into technical fields, but we can do a far better job than we have in the past in selecting talents that are capable of absorbing mathematical and scientific concepts to become leaders in their field in science and engineering. We must all agree that trained and creative human minds, the raw material of research and engineering, suddenly have become the nation's most critical resource. We face the necessity to encourage and develop to the fullest, all our human brainpower in scientific and technical fields. The frontiers of science have no forseeable limits.

We need an increasing number of engineers and scientists of inventive capacity who are able to break the bonds of traditional thought. Let us remember that creative ideas occur in the minds of single individuals. "Brainstorming" has its place in scientific laboratories in stimulating thought, but only individuals conceive new ideas. The laws of addition or multiplication of forces does not hold in the intellectual field. A single Einstein may accomplish a solution which hundreds of lesser men could never

attain. In the Manhattan Project two thousand scientists and engineers were needed to complete the task in the time allowed, but the towering talents of a relatively few men, such as Fermi, Bethe, Seaborg, Oppenheimer, Compton, and a few others, were decisive in setting the pace of the effort. Furthermore, industry and colleges need to stress the importance of advanced training, by providing exceptional men with tools to profit in the scientific field. One of our major problems today is that of quality rather than quantity of engineers.

Creative engineering has been defined as an insurance against capital loss. It is a treasure mine from which new sources of national wealth are constantly being uncovered. Although there are no new lands to explore, new frontiers are the frontiers of the mind. The unexplored fields of science awaits the courageous and persevering everywhere. In actual operation, creative engineering is very much like the man who hopes to get ashore by wading out into unknown depths, but when the water gets too deep he breaks out and swims on his own. All of us have within us varied measures of the urge to explore.

Creativeness is not the sole property of the inventor. In varying degrees it can be shared by all those engaged in technical participation. Genius cannot be created, but in the teamwork of industry, each branch or group contributes proportionately in a mass creative effort, but each individual must contribute. Engineers now have reason to believe that creativeness can be deliberate and that any engineer can create if he will learn, practice, and apply. Creativeness can become a habit of thinking. But to expand its usefulness it must be constantly nurtured and stimulated. There are many formulas advocated for developing the creative attitude. This phase of training is in an intensive state of development today.

Precepts have been developed by many imaginative engineering laboratories for solving problems and developing new concepts as a practical program of approach. One of the most successful training efforts has been operative at the General Electric Company. Based on experience, Mr. Purdy has this to say, "Creative capacity may be inherited. An individual's creative ability, however, can and must be developed to approach the limits of this capacity. One of the most misleading beliefs of our time is that you're creative or you are not, and there isn't much you can do about it. True, certain people may have more ability than others, but this is true in every field of activity. Einstein had more ability to understand complex mathematics than the average mathematician but we still teach mathematics; and Thomas Wolfe had greater than average ability to manipulate the written word, but we still teach English composition. Why, then, do we shun the teaching of creativity—especially in the field of engineering? Probably because we know very little about it."

In the solution of a problem in engineering, general objectives or goals are usually established with the assignment of the problem. This usually initiates step one in the engineering procedure, called recognition. It is the period of time that the engineer first becomes aware of the problem's existence.

Step two involves investigation. The problem having been recognized, the next step is to gain a more thorough understanding of the technical areas that might influence the solution.

A third step is described as definition, where the problem requires clar-

ification. Here a specification is established which the solution must fulfill, stating the conditions of solution.

A fourth step can be described as search. And here, reading in the field of interest is of tremendous value. Often an idea generated years ago may have failed for the want of sufficient knowledge, the availability of materials, or means of fabrication.

The fifth step can be called the origination step. During this phase of the work, the creative engineering program should have available a number of hypothetical solutions. This is probably the least understood of the various sequences in obtaining a problem solution, but it is by far the most important for it is at this time the individual, somehow, causes a new concept to blossom forth. At this stage prolific sketching of preliminary designs should be encouraged. Too often the engineer is satisfied with a single sketch and fails to develop the language of his mind into a design which progressively can be developed into a successful solution.

At no place is this more significantly demonstrated than in the Leonardo da Vinci Museum in Milan. In one showcase demonstrating da Vinci's notebook on the flight of birds, it is interesting to begin the sequence of sketches by the observance of the techniques of bird flight in normal straight flight. From here the sketching goes on to the maneuvers in which a bird operates and from there on to the more complex gyrations of bird flight. The notebook finally ends up with sketches which are concepts of the modern helicopter. The language of an engineer is a drawing or a sketch. His capacity to achieve and create is demonstrated by the progressive evolution of preliminary sketches into a composite design.

The sixth step has been defined as the evaluation step. At this phase an analysis or a separation into parts is essential, by which to ascertain the number of variables involved and develop experiments to resolve the complexity and reduce the number of variables to simple solvable projects. At this stage it is often desirable to construct models to observe under simple operating conditions, the more complex or obscure phenomena involved. For instance, the evaluation of turbulence in the combustion chamber of an internal combustion engine would be quite impossible to observe in cast iron structures blocking off a vision of the phenomena involved. A classical example of the utilization of physics experiments to resolve variable to their simplest determinations, are the experiments conducted on turbulence by Triebnigg. A horizontal trough was employed to simulate a cylinder and cylinder head. On the cylinder head end of the trough various configurations of combustion chambers were designed. A piston was placed into the trough, fitted with a wooden head which was carved and shaped to suit the progress of the experiment. The piston was actuated by connecting rod and crank. Between the walls of the trough and the piston head, water was poured and the motion of the piston created turbulent currents of the water as the piston approached the cylinder head. By sprinkling the surface of the water with aluminum dust it was possible, by photography, to make records of these turbulences. This experiment gave a two-plane analysis of a three-plane phenomena, but by the utilization of the principle of similitude, a multiplying factor could be employed to the velocities, the mass flows, and accelerations in such a way that a direct application could be made to engine operating conditions.

A seventh stage can be defined as the selection stage where it becomes

necessary to select one of the evaluated solutions as a final answer. The continual process of evaluating and selecting will ultimately reduce the number of ideas to one superior solution. In order to achieve this status it may be necessary to make analogous laboratory experiments to provide the opportunity of measuring the best selected method for solving a problem. This can be expressed by work done at the University of Aachen on Earth-moving Research. The problem of evaluating the amount of power required to remove earth by a blade has often been confused with the power required to fill the bowl of a self-propelled scraper. By setting up a compacted earth mass in a channel similar to a model basin used for evaluating ships forms and the propulsion power necessary to move a ship's hull through water, gave impetus to the development of earth-moving methods, both new and novel. A simple blade without any activated motion requires approximately 40% more power than the blade vibrated by supersonic means. The selected blade form and its motivation were far simpler in an experiment of this kind than in an actual full model demonstration.

Before proceeding with full model solutions it is often highly advantageous at this stage, to promote verbal exchanges with other individuals and groups in order to discuss various viewpoints for achieving creative results. Also testing opposites for analyzing the unconventional possibility, or the opposite method of achieving solution, can offer stimulating answers and reduce the number of evaluated solutions to a minimum. At this stage it is often desirable to resort to pencil and paper an analysis means. The story is told of a problem which involved the expenditure of $40,000.00 as a selected experimental solution, but which resolved itself in a pencil and paper analysis—at greatly reduced cost.

The next step is that of presentation, and here it is significant that there is often great difficulty in selling a new idea to management. The actual problem of finding a satisfactory functional solution is often less difficult than finding a solution that is considered feasible by management and one that is deemed suited by them to market conditions. In practical everyday life it has been found necessary to maintain a high level of creative thinking among the staff as well as management. Creative thinking flourishes best in a climate where unusual and unrestrained ideas are encouraged. Management should be aware that the staff be constantly reminded to be on the alert for the exceptional, the non-conforming, and to be encouraged to pursue assiduously the questioning of established principles and dogma.

In citing an example of the advantages of creative thinking, Dr. Danzig refers to a group problem on: "How to Eliminate Dishwashing." One ceramics engineer came up with the solution of using plates made of a gelatinous substance so that at the conclusion of the main course the plates could be eaten for dessert. Now, this seems ridiculous, but this is exactly the same idea that netted an Italian chef a huge sum of money for his invention of the ice cream cone.

It takes intestinal fortitude to live the life of creative thinking. One spends so much time in the region of failure that the price of success comes high, but it is worth it. "Imagination accounts for the survival of the fittest." Unfortunately, this is not fully appreciated by the millions of our young men who every day resign themselves to sterile drudgery by thoughtlessly ignoring or blandly defaulting the

marvelous faculty of imagination, and thus fail to reap its harvest in creativity.

We have passed through the age of random creativeness and are entering an age of deliberate creativeness. With this technique at our disposal, engineers will be able to accomplish much more in the future than they have in the past. This applies to all phases of engineering activity: research, design, manufacturing, sales, and management. Creative thinking is a process for achieving by the application of self-generated ideas. Its application is by no means the sole province of research or engineering departments. As a matter of fact, research and engineering often degenerate into non-creativeness by regulations, and border on imitation when imagination is neglected.

Experience of a large number of industrial research organizations and research institutes, indicate:

1. Practice will increase one's native ingenuity.
2. Practice encourages confidence and combats the mental block resulting from fear of unfamiliar solution.
3. Most problems do not require genius but concentrated hard work-thinking on paper.
4. The actual problem is to learn and to practice creativeness.

The engineer naturally should possess a probing curiosity. Like Pandora and her golden casket, one must have a desire to seek hidden knowledge. Pandora, one will recall, was warned by Mercury that the beauty of the casket was to be admired, but under no circumstances was it to be opened. Pandora was overcome by the same desire as the scientists to finally open and learn the secret of the chest. She stressed the lid only a little and out flew the insect which gave the sting of suspicion, hatred, fear, and malice. Only when the box was opened wide was the radiant butterfly released, the butterfly that soothed the sting of the insects, for the butterfly's name was Hope. So it is with the discoveries of science. Only when the full truth is learned can new and unexpected hopes appear.

The eminent astronomer, George Gamow, has said, "It took less than an hour to make the atom; a few hundred million years to make the stars and planets, but three billion years to make man."

Our problem is a fundamental one: How to reconcile man who has changed so little through the ages of time, with the machine which was born only yesterday? With the rich background of evolutionary development which is our heritage, the problems of our period should be amenable to solution. The future will then provide newer and more inviting challenges to attack. In the spirit of cooperation which has been so richly manifested in ASME, and our other professional engineering societies, we can continue to achieve if we have but the will to do, the discipline to think creatively.

Teaching Tip

A NOTE ON DIMENSIONS

G. M. DUSINBERRE

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University Park, Pa.

Very often we oversimplify the matter of physical dimensions, and thus make trouble for our students.

For example, what are the dimensions of work? Force times distance? Then what are the dimensions of torque? Same thing? But we need a factor of θ to find the work done by a given torque. Is this factor dimensionless?

Properly, we should say that the dimensions of work are force times a tangential distance, $W = FL_t$. Torque is force times a normal distance, $T = FL_n$. An angle, then, is not dimensionless: $\theta = L_t/L_n$.

By derivation, the property of thermal conductivity has the dimensions:

$$\frac{Q\ (\text{Btu})}{t\ (\text{hr})\ L^2_n\ (\text{ft}^2)\ T\ (^\circ\text{F})} \qquad L_t\ (\text{ft})$$

It is an oversimplification to cancel a "tangential" foot against a "normal" foot. It leads to confusion when the student encounters the very common and reasonable industrial practice of expressing the tangential dimension in inches.

In the study of convection, a term which arises variously is:

$$\frac{hL}{k}$$

But we may have k_{fluid} or k_{solid}. If k_{fluid} is involved, the ratio is known as the Nusselt number. If k_{solid} is involved, it still might be called a Nusselt number, and sometimes is so called. However, for that situation, some purist thought up the title, Biot number, and that name is also used.

I recommend to the purists that they work on a situation which causes a good deal more confusion than the above. This concerns the old familiar Reynolds number. There are two distinct varieties:

$$\frac{L_t V \rho}{\mu} \quad \text{and} \quad \frac{L_n V \rho}{\mu}$$

There are textbooks and papers in which the author switches back and forth between these two without the slightest warning. These physically distinct ratios should have different names, or at least should always carry an identifying subscript.

ATTEND
THE ASEE ANNUAL MEETING
UNIVERSITY OF CALIFORNIA, BERKELEY
JUNE 16–20, 1958

SOCIETY FOR HISTORY OF TECHNOLOGY

Members of the ASEE are cordially invited to join the newly-founded Society for the History of Technology, which is devoted to the study of the development of technology and its relations with society and culture.

The Society for the History of Technology will co-sponsor the program of the Humanistic-Social Division of the American Society for Engineering Education at Berkeley, which will be as follows:

Monday, June 16: "The Role of the Technical Museum in Engineering Education," Robert Multhauf, Head Curator, Science and Technology, Smithsonian Institution.

"Engineering Concepts in the Development of Thermodynamics," Thomas S. Kuhn, University of California.

Tuesday, June 17: "Relations of Science, Technology, and Art in Nineteenth Century Building," Carl W. Condit, Northwestern University.

"Technology and Cultural Values in American History," Edward Lurie, University of Michigan.

In the Fall of 1959 the Society will begin publication of a quarterly journal, *Technology and Culture*. Applications for charter membership ($10) in the Society for the History of Technology should be sent to Professor Melvin Kranzberg, Room 315, Main Building, Case Institute of Technology, Cleveland 6, Ohio.

ACCREDITATION PROGRAM FOR ANNUAL MEETING

Last fall in Detroit, the ASME Education Committee assembled approximately 90 prominent industrial people and educators for the purpose of better acquainting them with the importance of accreditation—its methods and procedures.

The strictly accreditation portion of this meeting consisted of a statement on the philosophy of accreditation by Dean W. L. Everitt and a case history of an accreditation inspection of a hypothetical university. This skit was most ably presented by Professor Newman A. Hall, Chairman of Mechanical Engineering Department, Yale University, Richard G. Folsom, President of Rensselaer Polytechnic Institute, and John H. Bushton of Purdue University. The method of presentation was highly informative, and because of its human interest values, as portrayed in the skit, it had excellent penetration into the minds of all present. Also, because of its fine success, it was suggested by many of those present that the program be repeated at appropriate places. One of these repeat programs will occur at a general session of the ASEE, Tuesday morning, at 9:30 A.M., June 17, at the Annual Meeting of the ASEE in Berkeley, California.

NEW MEMBERS OF ASEE

As of March 18, 1958

ALBRIGHT, CHARLES D., Instructor in Mechanics, West Virginia University, Morgantown, West Va. George W. Weaver, Carl H. Cather. Mech. & Mat'ls; M. E.

AUSTIN, GEORGE A., Instructor in Electrical Engineering, Purdue University, West Lafayette, Ind. Andrew P. Sage, Jr., Fritz J. Friedlaender. E. E.; Math.

ATALLAH, SAMI I., Instructor in Chemical Engineering, Tufts University, Medford, Mass. Leighton B. Smith, Kenneth N. Astill. Ch.E.; Chem.

BRIEN, FREDERICK B., Associate Professor of Mineral Engineering, University of Washington, Seattle, Wash. Drury A. Pifer, James I. Mueller. Min. Tech.; Ch. E.

BROOKINS, JACK E., Supervisor, School of Technical Associates, Oregon Technical Institute, Klamath Falls, Ore. K. L. Holderman, W. Leighton Collins. Adim., Educ.; Tech. Inst.

BRYAN, JOHN L., Professor and Head of Fire Protection Curriculum, University of Maryland, College Park, Md. F. T. Mavis, Louis E. Otts, Jr. Psych.

BURGERS, JOHANNES M., Research Professor, Institute for Fluid Dynamics, University of Maryland, College Park, Md. F. T. Mavis, R. B. Allen. Phys.; Math.

CHILINGAR, GEORGE V., Assistant Professor of Petroleum and General Engineering, University of Southern California, Los Angeles, Cal. Martin J. Siegel, George T. Harness. Min. Tech.; G. E.

CHITWOOD, PAUL H., Instructor in Electronics Technology, Oregon Technical Institute, Klamath Falls, Ore. K. L. Holderman, W. Leighton Collins. Tech. Inst.; Electronics.

COCHRUN, BASIL L., Assistant Professor of Electrical Engineering, Northeastern University, Boston, Mass. Martin W. Essigmann, Ronald E. Scott. E. E.

CRIBBINS, PAUL D., Instructor in Civil Engineering, Purdue University, Lafayette, Ind. K. E. Botkin, J. N. Arnold. C. E.; Engr. Dwg.

CUSTER, BROOKS O., Chairman of Highway Technology, Oregon Technical Institute, Klamath Falls, Ore. K. L. Holderman, W. Leighton Collins. Tech. Inst.; C. E.

DUWANE, WALTER H., Instructor in Electronics, Oregon Technical Institute, Klamath Falls, Ore. K. L. Holderman, W. Leighton Collins. Tech. Inst.

EDWARDS, CHARLES H., JR., Associate Professor of Civil Engineering, Louisiana Polytechnic Institute, Ruston, La. Richard A. Smith, R. A. McFarland. C. E.

FLACK, JOHN E., Assistant Professor of Civil Engineering, University of Colorado, Boulder, Colo. Robert J. Williams, Herbert E. Johnson. C. E.; Mech. & Mat'ls.

FONDAHL, JOHN W., Assistant Professor of Civil Engineering, Stanford University, Stanford, Cal. Boynton M. Green, C. H. Oglesby. C. E.

FOULON, CHARLES F., Curricular Chairman—Surveying, Oregon Technical Institute, Klamath Falls, Ore. K. L. Holderman, W. Leighton Collins. Tech. Inst.

FREMED, RAYMOND F., Associate Editor, Engineering Practice, "Chemical Engineering," Far Rockaway 91, N. Y. Sidney D. Kirkpatrick, Kenneth I. Zeigler. Ch. E.; I. E.

GALE, ALFRED R., Director of Technical Institute, Oregon Polytechnic Institute, Portland 4, Ore. Eugene Wood Smith, Omer K. McCaleb. Adim., Educ.; Tech. Inst.

GENCSOY, HASAN T., Assistant Professor of Mechanical Engineering, West Virginia University, Morgantown, West Va. James F. Hamilton, R. D. Slonneger. M. E.; Engr. Dwg.

HANSEN, EDWIN L., Professor of Agricultural Engineering, University of Illinois, Urbana, Ill. James O. Curtis, Keith Hinchcliff. Agr. Engr.

HARRIS, EDWARD H., Associate Professor of Mechanical Engineering, Tulane University, New Orleans, La. Lee H. Johnson, Walter E. Dessauer. Mech. & Mat'ls; G. E.

HEEBINK, DAVID W., Assistant Professor of Industrial Engineering, Stanford University, Stanford, Cal. W. Grant Ireson, Eugene L. Grant. I. E.; Engr. Econ.

HOLDREDGE, RUSSELL M., Instructor in Mechanical Engineering, University of Colorado, Boulder, Colo. Robert J. Williams, Herbert E. Johnson. M. E.

HUNNER, WESLEY, L., Assistant Professor Humanistic Social Department, University of Washington, Seattle, Wash. Jay F. Higbee, Stuart W. Chapman. Hum.-Soc.

LENTZ, OSCAR H., Assistant Professor of Economics, Colorado School of Mines, Golden, Colo. Frank R. Campbell, Carl G. Nordquist. Hum.-Soc.; Econ.

MITCHELL, CHARLIE R., Instructor in Civil Engineering, West Virginia University, Morgantown, West Va. Jerry C. Burchinal, H. W. Speider. C. E.; Mech. & Mat'ls.

MOLL, RICHARD E., Instructor in Civil Engineering—Graphics, Purdue University, Lafayette, Ind. K. E. Botkin, H. C. Thompson, Jr. Engr. Dwg.; Shop & Mech. Arts.

MONKE, EDWIN J., Instructor in Agricultural Engineering, University of Illinois, Urbana, Ill. James O. Curtis, Keith Hinchcliff. Agr. Engr.

MCFADDEN, JAMES A., Associate Professor of Electrical Engineering, Purdue University, Lafayette, Ind. Fritz J. Friedlaender, John E. Gibson. E. E.

MCGARRAH, JAMES E., Assistant Professor of Engineering Drawing, Agricultural and Mechanical College of Texas, College Station, Tex. W. E. Street, B. A. Hardaway. Engr. Dwg.

MCKEE, ALBERT G., Assistant Professor of General Engineering, Louisiana Polytechnic Institute, Ruston, La. H. L. Henry, Jr., Arthur C. Thigpen. Engr. Dwg.; I. E.

MCVEY, ALBERT V., Head, Department of Engineering Associates, Oregon Technical Institute, Klamath Falls, Ore. K. L. Holderman, W. Leighton Collins. C. E.; M. E.

NORDSTROM, JOSEPH A., Associate Professor of Industrial Engineering, Northeastern University, Boston, Mass. W. T. Alexander, A. E. Keating. I. E.

OAKFORD, ROBERT V., Associate Professor of Industrial Engineering, Stanford University, Stanford, Cal. W. Grant Ireson, E. L. Grant. I. E.

OLSON, DONALD R., Associate Professor of Mechanical Engineering, Yale University, New Haven, Conn. Newman A. Hall, L. E. Lichty. M. E.

ORRELL, DONALD B., Department Head of Electronics Technology, Oregon Technical Institute, Klamath Falls, Ore. K. L. Holderman, W. Leighton Collins. Adm., Educ.; Tech. Inst.

PEART, ROBERT M., Assistant Professor of Agricultural Engineering, University of Illinois, Urbana, Ill. Ralph C. Hay, James O. Curtis. Agr. Engr.

PICKARD, GEORGE E., Professor Agricultural Engineering, University of Illinois, Urbana, Ill. Keith Hinchcliff, James O. Curtis. Agr. Engr.

PURVINE, WINSTON D., Director, Oregon Technical Institute, Klamath Falls, Ore. K. L. Holderman, W. Leighton Collins. Adm., Educ.; Tech. Inst.

Ross, JAMES B., Manager of College Department, Reinhold Book Division, 430 Park Ave., New York 22, N. Y. Fred P. Peters, C. E. Littlejohn. Adm., Indus.

SCHMIDT, FRANK W., Instructor in Mechanical Engineering, University of Wisconsin, Madison, Wis. S. T. Hsu, D. W. Nelson. M. E.

SEELEY, CHARLES T., Instructor in Engineering Graphics, Purdue University, Lafayette, Ind. Warren J. Luzadder, Kenneth E. Botkin. Engr. Dwg.; Aero. & Aero. E.

SHERLING, WILLIAM G., JR., Associate Professor of Aeronautical Engineering, Alabama Polytechnic Institute, Auburn, Ala. J. E. Hannum, Marvin O. Williams. Aero. E.

SILBERBERG, MORRIS D., Lecturer in Drafting, The City College of the City of New York, N. Y. Frank A. Rappolt, Andre Halasz. Engr. Dwg.; C. E.

THOMPSON, RICHARD P., Instructor in Engineering Graphics, Purdue University, Lafayette, Ind. W. O. Satterley, K. E. Botkin. Engr. Dwg.; I. E.

VAUGHT, NEELEY R., Professor of Engineering Drawing, Odessa College,

Odessa, Tex. W. E. Street, John P. Oliver. Engr. Dwg.; C. E.

WARNER, BURDETT W., Instructor in Mechanical Engineering, University of Pittsburgh, Pittsburgh 13, Pa. Theodore W. Mishtal, William Rudoy. M. E.

WEBSTER, KARL S., Assistant Professor of Mechanical Engineering, University of New Hampshire, Durham, N. H. E. T. Conova, T. S. Kauppi. M. E.

WILLIAMS, TYLER E., JR., Industrial Engineer, Ordnance Management Engineering Training Program, Rock Island Arsenal, Rock Island, Ill. L. W. Wallace, Irvin P. Lazarus. I. E.

50 new members

As of April 1, 1958

ALVAREZ, RAUL E., Instructor in Industrial Engineering, North Carolina State College, Raleigh, N. C. Clifton A. Anderson, Robert G. Carson, Jr. I. E.

ANDERSON, JAY W., Instructor in Mechanical Engineering, University of Washington, Seattle, Wash. B. T. McMINN, J. P. Thomas. M. E.

AUSTIN, JOHN B., JR., Assistant Professor of Mechanical Engineering, Case Institute of Technology, Cleveland, Ohio. Anthony R. Konecny, Everett L. Laitala. M. E.

BONILLA-TORRES, ROGELIO, Associate Professor of Civil Engineering, University of Puerto Rico, Mayaguez, P. R. H. Marti-Marini, F. Acaron-Ortiz, C. E.

BRENNAN, RICHARD E., Associate Editor, College Department, Addison-Wesley Publishing Company, Inc., Reading, Mass. John F. Lee, J. S. Doolittle. English; G. E.

CHALK, WILLIAM S., Acting Instructor in Mechanical Engineering, University of Washington, Seattle, Wash. B. T. McMinn, J. P. Thomas. M. E.

CHOW, WEN L., Research Assistant Professor of Mechanical Engineering, University of Illinois, Urbana, Ill. John A. Henry, J. W. Bayne. M. E.; Aero. & Aero. E.

CRAIN, RICHARD W., SR., Associate Professor of Mechanical Engineering, University of Washington, Seattle, Wash. James B. Morrison, William B. Nordquist. M. E.

DEPAUW, JOHN F., Technical Employment, Minnesota Mining and Manufacturing Company, St. Paul 6, Minn. W. W. Burton, B. C. Baker. Adm. Indus.

DEVRIES, LOUIS S., Assistant Professor of Engineering, Pan American College, Edinburg, Tex. L. A. Youngman, F. H. Dotterweich. G. E.; Agric. E.

DUFFEY, DICK, Associate Professor of Chemical Engineering, University of Maryland, College Park, Md. F. T. Mavis, G. F. Corcoran. Ch. E. (Nuclear).

EDIS, ALFRED R., Associate Professor of Mechanical Engineering, McGill University, Montreal, Quebec, Canada. J. B. Phillips, W. H. Gauvin. M. E.

FEHLMANN, ALFRED B., JR., Instructor in Technical Institute, University of Dayton, Dayton, Ohio. D. C. Metz, J. L. McGraw. Tech. Inst.; Math.

FORD, PAUL W., Acting Instructor in Mechanical Engineering, University of Washington, Seattle, Wash. B. T. McMinn, J. P. Thomas. Mechs. & Mat'ls; I. E.

FORSYTH, RAYMOND A., Instructor in Civil Engineering, Alabama Polytechnic Institute, Auburn, Ala. Henry R. Thacker, Earl I. Brown II. C. E.; Engr. Dwg.

FRANTILLA, WILLIAM L., Instructor in Mechanical Engineering, University of Washington, Seattle, Wash. B. T. McMinn, J. P. Thomas. M. E.

GAITHER, ROBERT B., Instructor in Engineering, University of Illinois, Urbana, Ill. John A. Henry, J. W. Bayne. M. E.; G. E.

GREENBERG, AARON J., Instructor in Civil Engineering, Washington University, St. Louis, Mo. D. Ryckman, A. W. Brust. C. E.

HEIDEGER, WILLIAM J., Assistant Professor of Chemical Engineering, University of Washington, Seattle, Wash. Morton M. David, R. W. Moulton. Ch. E.; Engr. Econ.

HOLT, RICHARD E., Assistant Professor of Mechanical Engineering, University of Washington, Seattle, Wash. B. T. McMinn, J. P. Thomas. M. E.; I. E.

HRUBECKY, HENRY F., Associate Professor of Engineering Mechanics, University of Florida, Gainesville, Fla. William L. Sawyer, Thomas O. Neff. Mechs. & Mat'ls.

JACOBS, ROBERT M., Assistant Professor of Mechanical Engineering, Newark College of Engineering, Newark, N. J. J. H. Weinstein, T. A. Schneider. M. E.; Aero. & Aero. E.

JOHNSON, FRANKLIN B., Assistant Professor of Architectural Engineering, University of Texas, Austin, Tex. W. W. Dornberger, Jack Lenhart. Arch. E.; C. E.

JOLY, GEORGE W., Assistant Dean of Engineering, McGill University, Montreal, Quebec, Can. J. B. Phillips, W. H. Gauvin. Adm. Educ.

KEEN, EDWARD C., Instructor in Engineering, The Pennsylvania State University, University Park, Pa. W. A. Dunn, V. E. Neilly.

KELLY, PATRICK J., Instructor in Electrical Engineering, Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. Richard F. Schwartz, Harry Sohon. E. E.; Math.

KENNY, LYLE D., Instructor in Mechanical Engineering, University of Washington, Seattle, Wash. B. T. McMinn, J. P. Thomas. M. E.

KLETSKY, EARL J., Instructor in Electrical Engineering, Syracuse University, Syracuse, N. Y. E. V. Kosso, Sakari T. Jutila. E. E.; Math.

LANDRUM, ROBERT D., Assistant Professor of Physics, University of Dayton, Dayton, Ohio. Donald C. Metz, James L. McGraw. Tech. Inst.; Phys.

LEWIS, RODNEY C., Associate Professor of Electrical Engineering, University of Southern California, Los Angeles, Cal. Martin J. Siegel, George T. Harness. E. E.

LINK, ROBERT P., Associate Dean of College of Fine and Applied Arts, Associate Professor of Architecture, University of Illinois, Urbana, Ill. Chu-Kia Wang, Linwood J. Brightbill. Adm. Educ.; Arch.

LUX, WARREN E., Coordinator, Recruiting Department, Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Bruce J. Miller, C. J. Metz. Adm. Educ.; Chem.

METZGER, IVAN, Instructor in Civil Engineering, Newark College of Engineering, Newark, N. J. James M. Robbins, Richard D. Mangasarian. C. E.

MIKHAIL, SAAD L., Assistant Professor of Electrical Engineering, University of California, Berkeley, Cal. Henry C. Bourne, Jr., Otto J. M. Smith. E. E.; Math.

MCARTHUR, HAROLD R., Associate Professor of Applied Mechanics, University of Alberta in Calgary, Alberta, Canada. Dean Robert M. Hardy, W. Leighton Collins. C. E.; G. E.

OSTAPENKO, ALEXIS, Assistant Professor of Civil Engineering, Lehigh University, Bethlehem, Pa. E. C. Sword, R. H. Seeger. C. E.

PETERSON, DONALD A., Technical Writer, Hughes Aircraft Company, Tucson, Ariz. F. O. Woodsome, B. H. Spurlock, Jr. M. E.; Management.

PUTNAERGLIS, RUDOLPH, Assistant Professor of Mechanical Engineering, McGill University, Montreal, Quebec, Canada. J. B. Phillips, W. H. Gauvin. M. E.; E. E.

REED, HENRY R., Professor of Electrical Engineering, University of Maryland, College Park, Md. F. T. Mavis, G. F. Corcoran. E. E.; Math.

SHOUMAN, AHMAD R., Assistant Professor of Mechanical Engineering, University of Washington, Seattle, Wash. James B. Morrison, B. T. McMinn. M. E.; I. E.

SKUTT, HENRY R., Assistant Professor of Electrical Engineering, Virginia Polytechnic Institute, Blacksburg, Va. John P. Gordon, Mansell H. Hopkins. E. E.; Physics.

SMITH, CECIL H., Associate Professor of Civil Engineering, Southern Methodist University, Dallas, Tex. John A. Savage, H. Charles Baker. C. E.; Mechs. & Mat'ls.

SMITH, NELSON S., JR., Instructor in Electrical Engineering, West Virginia University, Morgantown, West Va. Ralph H. Theophilus, E. C. Jones. E. E.

SNYDER, WILLIAM A., Associate Professor of Mechanical Engineering, University of Washington, Seattle 5, Wash. B. T. McMinn, J. P. Thomas. M. E.

VAN WINGEN, N., Professor of Petroleum Engineering, University of Southern California, Los Angeles, Cal. Martin J. Siegel, George T. Harness. Min. Tech.-Petrol.

VEAL, DONALD L., Instructor in Civil Engineering, South Dakota State College, Brookings, S. Dak. Emory E. Johnson, Paul L. Koepsell. C. E.

VELEZ, ENRIQUE, Instructor in Electrical Engineering, Tri-State College, Angola, Ind. Arthur Eberhardt, Clyde E. Shaw. E. E.

WEBB, GEORGE W., Assistant Professor of Electrical Engineering, Tulane University, New Orleans, La. James A. Cronvich, R. L. Drake. E. E.

WINCHELL, ROBERT, Assistant Professor of Electrical Engineering, University of Southern California, Los Angeles, Cal. Martin J. Siegel, George T. Harness. E. E.

ZUMWALT, GLEN W., Research Associate in Mechanical Engineering, University of Illinois, Urbana, Ill. John A. Henry, J. W. Bayne. M. E.; Aero. & Aero. E.

100 new members this list
801 members previously added this year

901 new members this fiscal year

SAVILLE TO DIRECT FLORIDA STUDY

The University of Florida has announced the appointment of Dr. Thorndike Saville as Director of a Science and Engineering Center Study. The study is sponsored by a Ford Foundation grant, and is designed to develop a center for graduate study and research in which the pure and applied sciences may be coordinated, utilizing the unique situation at the University, where the Colleges of Agriculture, Engineering, Liberal Arts, Medicine, and other professional schools occupy the same campus.

Dr. Saville requested to be retired as Dean of the College of Engineering at New York University in September 1957 in order to devote more time to consulting engagements in his specialties of water resources development and administration, and coastal engineering. In his new post Dr. Saville will continue to be available for limited consulting engagements to engineering firms and government agencies. *His address after March 1, 1958 will be*— Room M-135, Medical Sciences Building, University of Florida, Gainesville, Florida.

TEACHING POSITIONS AVAILABLE

CIVIL ENGINEERING OR MECHANics—Associate and Assistant Professors and Instructors needed. M.S. degree desirable but instructors working toward advanced degrees considered. Salaries for nine months academic year, paid in ten installments, based upon experience and education. Start September, 1958. Applications for a position as Instructor in Engineering Drawing, Descriptive Geometry, and Surveying will also be considered. Write Earl D. Dake, South Dakota School of Mines and Technology, Rapid City.

HIGHWAY ENGINEERING SPEcialist to teach highway and transportation engineering courses with opportunity to engage in highways research work. Taking charge of surveying courses is also a possibility, although not a requisite. Development of Highway Engineering Laboratory as part of Fritz Engineering Laboratory is contemplated and would be part of the challenge this position affords. Write Department Head and Director, Fritz Engineering Laboratory, Lehigh University, Bethlehem, Penn.

MECHANICAL ENGINEERING FACulty needed for courses in thermodynamics, heat transfer, fluid mechanics, and laboratories. Also electrical engineering faculty needed qualified in power engineering, basically in the field of circuits. Someone in electronics could be used. Persons should have teaching and industrial experience. Salary and rank dependent upon degree and experience. Positions new open. Apply to Dr. Hildred B. Jones, Dean of University, Ohio Northern University, Ada, Ohio.

ENGINEERING FACULTY OPPORtunities at midsoutheastern college. Openings available in all departments. M.S. or Ph.D. preferred. Salary commensurate with training and experience. Appointment at the beginning of any quarter except summer. Apply: School of Engineering, Tennessee Polytechnic Institute, Cookeville, Tennessee.

ELECTRICAL ENGINEERING OPENings for September, 1958. Modern curriculum, expanding department. Reasonable teaching load. Rank and salary dependent upon training and experience. Write John B. Clothier, Jr., Acting Head of Electrical Engineering Dept., Villanova University, Villanova, Penna.

COURSES IN MECHANICS AND Electricity. M.S. or B.S. degree, starting in September. Salary scale good, commensurate with qualifications. Moving expenses paid. Liberal vacation. Opportunity for advancement. Apply to: Head, Department of Mechanics and Electricity, Montana School of Mines, Butte, Montana.

ELECTRONIC ENG. AND PHYSICS. Associate and assistant professor for undergraduate and graduate courses. Night and summer teaching available to supplement nine months salary. Research work in solid state, radio telescope, and instrumentation. Address Dr. C. R. Mingins, Chairman, Division of Engineering, Lowell Technological Institute, Lowell, Massachusetts.

REPORT OF ME DIVISION COMMITTEE FOR REVISION OF BY-LAWS

NEWMAN A. HALL
BRYANT T. McMINN
Chairman, V. L. DOUGHTIE

Italic sections are additions or changes adopted August 19, 1949.

OFFICERS' DUTIES

Division Officers

Chairman—Responsible for over-all program planning.

Coordinate activities of other officers and activities for the Division in liaison with other divisions and the Secretaries of the Society with regard to program planning.

Schedule, organize, and conduct executive committee meetings, including program-planning meeting held toward end of annual meeting.

Write annual report to Secretary of the Society, with copies to division and sub-division secretaries.

Vice-Chairman—Organize dinner meeting.

Be responsible for conduct of the election of Secretary.

See to it that Sub-Committee sessions are properly planned, start on time, and that speakers are properly cared for.

Secretary—Organize luncheon meeting.

Be responsible for performance of Sub-Committee Secretaries.

Secure papers from Sub-Committee Secretaries and

Bring copies of papers to Executive Committee for vote on which ones are to be published.

Submit papers to Division editors for publication in *Bulletin.*

See that complete records of all Division activities are kept, as well as records of finances.

Keep records and pass on to succeeding secretaries in good permannent form.

Report to Secretary *of the Society* on finances and on complete records of sessions at annual meeting.

Sub-Committee Officers

Chairman—Organize and operate respective sessions at annual meeting.

Vice-Chairman—Meet speakers at sessions.

Handle physical equipment at meetings.

Chairman of Nominating Committee for election of secretary.

Secretaries—Responsible for records of meetings, handling of papers, thank-you notes to speakers.

BY-LAWS

Division of Mechanical Engineering, ASEE

1. *Name.* The name of this Division shall be the Division of Mechanical Engineering of the American Society for Engineering Education.

2. *Purposes.* The purposes of this Division are identical with those of the Society as stated in Article 1 of the Constitution, but with special

emphasis on those objectives as they pertain to the field of Mechanical Engineering.

3. *Membership.* The membership of this Division shall consist of those members of the Society who wish to affiliate with this Division.

4. *Organization and Officers.* The Division is composed of subdivisions as follows:

(a) Heat Power
(b) Machine Design and Manufacturing *processes*

The division shall be administered by an Executive Committee composed of a Division Chairman, a Division Vice-Chairman, a Division Secretary, the Chairman of each of the subdivisions, *the retiring sub-division chairman who was not elected secretary of the division,* and the Division Representative on the General Council of the Society.

Each subdivision shall be administered by an executive committee consisting of a Chairman, a Vice-Chairman, a Secretary, and an Editor.

5. *Election of Officers.* The Chairman of the Division shall retire at the end of each annual meeting. He will automatically be succeeded by the Division Vice-Chairman. The Vice-Chairman shall be succeeded by the Secretary. A new Division Secretary shall be elected by secret ballot by the members of the Division present at the annual meeting, from retiring subdivision chairmen. The one receiving the highest number of votes will become the Division Secretary. *The other retiring subdivision chairman who was not elected as division secretary will become a member of the Executive Committee for one year.*

The Division Representative on the General Council of the Society shall be elected for a term of two years by a secret ballot of the members of the Division present at the annual meeting. *The nominees shall be the retiring division chairman and his immediate predecessor.*

At the end of each yearly period, the Chairman of each subdivision shall retire and be automatically succeeded by the Vice-Chairman. The Vice-Chairman shall be succeeded by the subdivision Secretary. A new Secretary of each subdivision shall be elected by the members of the subdivision at the time and place of the annual meeting, *from nominations made by the nominating committee. The nominating committee shall have the Vice-Chairman as chairman and the two other members appointed by the chairman of the subdivision.*

In addition to the methods specified above for providing for the Division and the Subdivision officers, additional names may be nominated for any office upon the presentation of such nominations signed by five members of the Division present at an annual meeting. These nominations shall be voted upon together with the names of the member who would normally succeed to the office in question.

The Editors of each subdivision shall be selected for terms of *two* years by the Executive Committee of the Division.

Each editor shall file with the subdivision and division secretaries a written report on his publication, including a financial statement, just before the annual meeting.

6. *Meetings and Activities.* The Executive Committee shall arrange for an annual conference of the Division to be held concurrently with the annual meeting of the Society.

The Executive Committee shall arrange special summer schools to be sponsored by the Society or by the Society and other cooperating societies.

The Executive Committee shall administer such other activities as may

be desirable for the promotion of the purposes of the Division, including the appointment of special temporary committees.

Members of the Society and other interested persons shall be eligible to attend all meeting of the Division.

7. *Publications.* The Heat Power subdivision may issue a publication entitled "Heat Power News and Views" which is directed by the editor of this subdivision.

The Machine Design and Manufacturing *Processes* subdivision may issue a publication entitled "Machine Design and Manufacturing Bulletin" which is directed by the editor of this subdivision.

All papers presented at meetings of the Division become the property of the Society and may be recommended for publication in the JOURNAL OF ENGINEERING EDUCATION or in the publications of the Division as is deemed proper by the Executive Committee of the Division. Papers not recommended for publication shall be returned to the authors and shall no longer be considered the property of the Society.

Subscription fees are to be sent to the respective Subdivision Editors, who are authorized to use such fees to defray publication, secretarial, and mailing costs of the Subdivision publications.

8. *Amendments.* Amendments to these by-laws may be adopted at any annual meeting of the Division upon an affirmative vote of two-thirds of the members present.

Proposed amendments are to be prepared by a committee of three members appointed by the Chairman of the Division. The amendments are to be sent to the members by letter or in the publications of the division not later than thirty days before they are to be voted upon.

A TEST FOR WRITING APTITUDE

(Continued from page 901)

various branches of science. Thus scientists, teachers, and students could acquire more diversified knowledge and a broader view. Many specialists might become generalists if we gave them a chance.

Summing up, I would like to offer for discussion the following suggestions for the improvement of scientific and technical communication:

1. Systematic testing of all scientific and technical personnel, including students, for writing aptitude, and special training in communication techniques of all those whose aptitude is better than average.

2. Gradual concentration of all scientific and technical communications in the hands of this trained minority.

3. Rigorous editing of all publications to make them clear, brief, and readable.

4. Elimination of prestige publications.

5. Development of tests for research and teaching aptitude and separation of these functions where this would improve the performance of individual scientists and teachers.

ABSTRACT OF THE MINUTES SPRING MEETING OF THE EXECUTIVE BOARD

The ASEE Executive Board held its spring meeting in conjunction with the annual meeting of the Southeastern Section at Miami Beach, Florida, on April 18 and 19, 1958. All members were present and President F. C. Lindvall presided; the officers-elect also attended.

New Members. An analysis of the 950 new members who have joined the Society during the current fiscal year indicates that they come from 289 different schools and a number of companies and governmental units. These totals are impressive, but when it is realized that, for the active member institutions in the continental United States, where the YETS are organized, the average number of new members per school is only *four*, it must be concluded that there still is a tremendous untapped source of new members. The largest number of new members is from the University of Illinois with 36; in second place is the University of Arizona with 29; nine other schools have 10 or more new members.

New Officers. The results of the letter ballot for national officers were reported and the Executive Board declared W. T. Alexander to be elected president for 1958–59; E. C. Easton, vice president for subject matter Divisions for 1958–60; C. L. Eckel, vice president for Sections west of the Mississippi River for 1958–60; and John Gammell, treasurer for 1958–59.

Subsidiary Units as Members. Membership in the Society for divisions and subsidiaries of parent corporations and units of educational institutions having different or separate programs, again was discussed. The Executive Board voted that if such subdivisions desired to become members, and if they met all qualifications established by the constitution and by-laws, there was no reason why they should not be elected to membership. The Executive Board also voted that a school which is not a member of the Society cannot be a member of a section, but may affiliate with a section and participate actively in its programs.

Non-voting Members of ECRC. ECRC requested that the representatives of industrial members become nonvoting members of ECRC, just as they now become nonvoting members of ECAC. The Executive Board approved and voted to refer the question to the Constitution and By-laws Committee to work out the details in consultation with ECRC.

Liaison With Other Engineering Societies. In order to improve the liaison with other engineering societies, particularly with their education and research committees, the Secretary was instructed to prepare a letter and consult with the chairmen of ECAC and ECRC regarding distribution.

Financial Report for the Third Quarter. Indications are that both receipts and disbursements probably will exceed the budget totals at the end of the year, but there still is a chance there will be no deficit at the year's end.

Six-year Study of Income and Disbursements. Both have increased steadily. The increase in expenditures is primarily in improved services to the members—the JOURNAL, officers attending Section meetings, travel allowance for the General Council, increased headquarters staff, and increased salaries. The quarterly report totals for the past few years

enable a fairly accurate prediction to be made of the income and disbursements for each quarter of the fiscal year.

Editor's Report. A backlog of suitable papers has accumulated, the number of pages of advertising is averaging about 1.2 pages under last year (this is good compared to the experiences of some other publications), and each issue of the JOURNAL has been mailed by about the middle of the appropriate month.

Indirect Costs for Research Contracts. A resolution was approved urging Congress to recognize that indirect costs on research contracts are real costs to universities and that the federal government should pay its fair share of such costs. The resolution is to be sent to Dr. J. R. Killian, Jr., Secretary Marion Folsom, and other appropriate individuals.

Divisional Organization. The divisional structure of the Society was discussed at some length, and the vice presidents in charge of divisions were instructed to study the matter of organization along functional lines and submit a preliminary report at the June meeting.

Annual Meetings. It was agreed that annual meeting programs should make full use of Monday morning in scheduling events, starting in 1959 at Pittsburgh. The letter ballot approval of the dates for the 1961 meeting at the University of Kentucky, June 26–30, was made a matter of record.

Summer Institutes. The Nuclear Committee was authorized to proceed with negotiations with the Atomic Energy Commission in sponsoring Summer Institutes for 1959. There was no feeling that significant changes in the basic plan need be made, but if radical changes develop they are to be submitted to the Executive Board for approval prior to the making of a final commitment. Institutes on nature and properties of materials, industrial uses of isotopes, and thermo-nuclear problems were suggested for future consideration.

Nuclear Committee. Authorization was granted to cooperate with the Oak Ridge Institute of Nuclear Studies to aid in the administration of the National Science Foundation fellowship plan. The Committee will develop principles for selection of institutions and prepare several examples of desirable types of curricula. Every precaution will be taken to avoid the concept of accreditation of curricula. It was suggested that all students be informed that they must carefully evaluate the programs offered by the institutions they expect to attend.

Effective Teaching Manual. A revision was discussed at some length. Because of the possible interest of Dr. J. R. Killian's panel on Education in Science and Engineering, it was finally agreed that ASEE should not push a revision now. This action does not reflect a lack of interest, but rather the lack of an appropriate individual to lead the most appropriate group to accomplish the job, as well as the lack of financial support.

Federal Legislation. The testimony presented to Congressional Committees was reviewed. It was agreed that the procedure was desirable and should be continued when invitations were received to testify on appropriate matters.

New Constitution of EJC. Copies were presented to all members of the Executive Board. It was agreed the approval should be by action of the General Council. The Secretary was instructed to get copies for all members of the General Council, and Vice President R. J. Woodrow was instructed to make the presentation to the General Council at the Monday night meeting at Berkeley. The EJC Secretary is to be invited to attend

the meeting, at EJC's expense, to discuss EJC and its work.

EUSEC. It was agreed that ASEE should publicize in its JOURNAL two reports pertaining to EUSEC. One is the report of the U. S. delegation and the other is the report of the Third Conference.

Educational Mission to Russia. The President is to continue exploring the possibility of ASEE sponsoring an educational mission to Russia. Details of State Department approval, the interest of the National Research Council, and a method of financing are the immediate problems requiring solution.

Appointment of Editor. Paul T. Bryant was appointed Editor on a half-time basis for one year, effective September 1, 1958. With the amount of time increased from 20 to 50 per cent, the editing of the ECRC Research Review and other Society publications, as well as the JOURNAL, was assigned to the Editor. Mr. Bryant currently is on the English staff of the University of Illinois, but next year will be dividing his time between the Office of the Dean of Engineering and ASEE. Prior to coming to Illinois he was, for two years, Technical Editor at the Washington State Institute of Technology, State College of Washington, Pullman, Washington.

Appointment of Secretary. W. Leighton Collins was reappointed Secretary for one year, starting July 1, 1958. The time devoted to ASEE is fifty per cent during the academic year and full-time during the summer and other vacations, with a one-month vacation to be accumulated during the year.

Study of the Teaching of English. At its own request the ad hoc committee to study the Teaching of English in Colleges of Engineering was discharged; no means of financing the study could be obtained.

Next Meeting. A dinner meeting of the Executive Board will be held at 6:30 p.m. on Sunday, June 15, at Berkeley, California.

Respectfully submitted,
W. LEIGHTON COLLINS
Secretary

PROGRAM FOR THE E.E. DIVISON, ANNUAL MEETING

Tuesday, June 17, 1958, 2 p.m.
Theme: Educating the Electrical Engineer of 1975

"The Curriculum Fundamentals"—J. R. Whinnery, University of California, Berkeley
"Philosophies of Curriculum Design"—Samuel Seely, Case Institute of Technology
"Implementing New Curricula"—Gordon S. Brown, M.I.T.

Wednesday, June 18, 1958, 2 p.m.
Theme: Physics in the E.E. Curriculum

"An Experiment in the Reduction of Physics Contents"—J. D. Ryder, Michigan State University
"The Place of Physics in the E.E. Curriculum"—T. L. Martin, University of Arizona
"Traditionalism in Undergraduate Physics Teaching"—W. W. Harman, Stanford University

SHORT COURSE IN STATISTICS

The Institute of Statistics at North Carolina State College will sponsor a one-week intensive short course in Statistics Methods for research workers in industry and the physical sciences beginning the week of June 16.

The course will be held at Brevard College in Brevard, N. C. An elementary and an advanced section will be offered.

Lectures in the elementary section will cover basic concepts, confidence limits, tests of significance, correlation and curve fitting, analysis of variance, and an introduction to design of experiments.

Among the topics included in the advanced section will be variance components, multiple regression, response methods, and experimental design.

A registration fee of $125.00 will be charged. Enrollment will be limited to 50 students in each section. For further information, write the Division of College Extension, Box 5125, State College Station, Raleigh, North Carolina.

OAS TO GRANT FELLOWSHIPS FOR FOREIGN STUDY

A new fellowship program offering grants for advanced study or research to specialists throughout the Western Hemisphere will be effected by the Organization of American States on July 1, 1958. The OAS program, recommended by the Inter-America Committee of Presidential Representatives, seeks to assist qualified persons by providing opportunities for pure research, and for improvement of professional skills through advanced study in foreign countries.

Applicants will be screened for professional or technical competence by the OAS General Secretariat, awards being made by the Secretary General. Grants will be awarded in the fields of most urgent needs expressed by member states, and a balanced distribution attempted. Awards will cover travel, registration and tuition fees, work materials, and subsistence, for durations ranging from three months to two years. Approximately 170 fellowships will be granted for 1958–59, with a minimum of 500 annually planned for the future.

Inquiries should be addressed to: Technical Secretary, OAS Fellowship Program, Pan American Union, Washington 6, D. C.

FACILITIES AND OPPORTUNITIES FOR GRADUATE STUDY IN ENGINEERING

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FACILITIES AND OPPORTUNITIES FOR GRADUATE STUDY IN ENGINEERING

A Report of the ASEE Graduate Study Commission

I. SUMMARY AND INTRODUCTION

The current scene in engineering education is characterized by rapid change brought about by the needs of a swiftly moving technology. The change is nowhere more marked, nor is it of more fundamental nature, than in the patterns of development of graduate study in engineering. Most of the studies in the past have been concerned with an evaluation of existing practice and have not dealt intensively with this factor of progressive development.

With this basic consideration in mind the Graduate Division of the American Society for Engineering Education proposed the establishment of an extensive investigation of the facilities and opportunities for graduate study in engineering with particular emphasis to be given to the trends for future development. This proposal was approved by the General Council of ASEE on June 14, 1954. The Graduate Division with the approval of the Council established a Steering Committee for the project which, in turn, appointed four Task Committees to investigate specific phases of the project. The Steering and Task Committees together comprise the Graduate Study Commission.

An initial meeting of the Commission was held at the Gould House of New York University on February 26, 27, and 28, 1956. At this meeting the scope of the project was intensively reviewed and defined. The Task Committees in turn outlined their studies. A second meeting of the Commission was held at the National Science Foundation in Washington on March 31, April 1 and 2, 1957. Each committee had submitted in advance drafts of their findings which were exhaustively analyzed by the Commission as a whole. On the basis of findings of the Task Committees an Interim Report of the Commission was prepared and widely distributed in June, 1957. This Final Report represents the results of further review by the Commission derived from its own reexaminations together with the recommendations submitted by the many others who received the Interim Report.

The plan of this study as outlined in the Table of Contents consists of five major sections: Status and Objectives; Motivation; Financing; Patterns of Graduate Study; and Development of Graduate Faculties.

It is the hope of the Commission that this study will establish constructive guide lines for the contributions which graduate study will make to the profession of engineering.

Acknowledgment is given to the General Electric Company for the financial support which has made possible the carrying forward of this study.

II. STATUS AND OBJECTIVES

The Background of Graduate Study in Engineering

A review and evaluation of graduate study in engineering must consider not only the changing situation which exists at present, but also the circumstances in the past which have produced the present pattern and the needs of the future which should be anticipated in assessing the trends which are now apparent. Fortunately, there have been extensive studies of engineering education such as the early Wickenden report and the more recent Grinter report on the Evaluation of Engineering Education which amply describe the history of engineering education and provide a basis for further examination.

The position of graduate study in engineering differs somewhat from that in other professional fields since the primary emphasis in the education of engineers has been on the undergraduate program. It has generally been considered that an undergraduate course in which the student receives an intensive training in principles and methods provided sufficient background for an engineer as an initial step in his career in the profession. Over a period of years a shift has taken place from training in technical skills to education in engineering science and in the synthesis of engineering systems.

The growing importance of graduate study has come about, not because of a transfer of basic training from the undergraduate to the graduate level, but rather through an enlargement of the field of knowledge involved and the increase of association with the sciences and mathematics. The present pattern of graduate study in engineering rests in all cases on the assumption that the student has a firm background in undergraduate engineering. This pattern is to be contrasted with that existing for other professions such as medicine, law, and the clergy, where, in view of substantial differences in historical development and professional needs, the primary training in the profession follows rather than coincides with the undergraduate program. This difference in accepted practice is a significant characteristic of engineering and is one of the major factors which complicate an evaluation of graduate study.

Since graduate study in the arts and sciences developed as further formal education beyond the undergraduate degree, the most common pattern in the initial development was the establishment of an engineering program within the framework of the existing graduate schools of arts and sciences, or at least under the administration of the graduate faculty. The standards and criteria for such a program were accordingly those normally accepted for other academic graduate degrees. The emphasis was on the advancement of knowledge rather than on the development of the specialized technical abilities required in the practice of engineering.

At the same time that the graduate programs in engineering were being established, there was a parallel introduction of the so-called professional engineering degrees. This arose from the need of some type of certification that an engineering graduate, by virtue of experience in the practice of engineering, was in a position to assume full professional responsibility in his field. The requirements for these degrees differed greatly among institutions, and were primarily related to substantial evidence of high competence in practice. For a number of years a real need was accom-

modated in this way. However, in recent years the growth of professional engineering registration has tended to reduce the need for non-academic degrees.

It should be stressed, however, that formal education at the graduate level is accepted more and more as desirable background for engineering practice. While an undergraduate program is essential in all cases, it appears that the rapid increase in emphasis on graduate studies is associated with the expansion of research and development in engineering, and increasing application of sciences in the analysis of complex engineering tasks. The engineer with the graduate degree is better able to examine the practice of engineering in a constructively critical manner and has contributed much in bringing ideas from the sciences into the methods of engineering analysis and design. In recent years the problems of both civilian industry and the military services have been of such a nature as to demand for their solution the application of all the scientific knowledge available. This situation calls for knowledge and training which cannot be adequately provided by undergraduate training alone nor in the most efficient manner by active practice. The graduate program in engineering is being called upon to meet this need.

The status of graduate study in engineering has received considerable attention in earlier reviews of engineering education. In addition to the Wickenden and Grinter reports which discussed graduate work as one aspect of the over-all picture, the Manual of Graduate Study in Engineering prepared by the Graduate Committee of the ASEE was originally issued in 1945 and revised in 1952. This study is the most intensive examination which has appeared and, although there have been substantial changes since that date, it provides an essential starting point for the present work.

The Present Status of Graduate Study

At the present time engineering graduate studies are still much closer in organization and administration to the customary academic graduate school operation than to professional schools such as those of law or medicine. This is true even in the many cases where the graduate program is integrated with the engineering school or college rather than with the graduate school in arts and sciences. For this reason engineering graduate programs exhibit a comparable pattern of requirements and academic controls. This same tradition applies to the various programs of extended service discussed more fully later which provide evening and off-campus courses.

If the academic tradition were the sole controlling factor, the questions arising with respect to graduate study in engineering would be no different from those in the arts and sciences. However, the professional aspects of engineering produce significant modifications, one of the most important of these being the demand that graduate study be extended not only in numbers of students, but also in diversity of service. This pressure comes from all parts of the profession, from industry, from government and from the prospective graduate student. In order to expand, a first consideration has necessarily been the need for financial support adequate to provide competent staff, facilities, and student subsidies.

Two major factors in addition to direct pressure from the engineering profession substantially affect the current development of graduate study in engineering. These are the expansion of sponsored research and the

growth of diverse patterns of graduate study providing extended service to many who would not otherwise have access to graduate study.

Sponsored research, receiving support primarily from the federal government but in many cases from industry as well, has made possible significant extensions of graduate engineering operations at many institutions. Not only has substantial financial support been provided, but the stimulus of increased research activities has made possible an accelerated growth of graduate programs in engineering. The administration of sponsored research has become a major responsibility in itself at many institutions, so that while the opportunities for graduate research may be enhanced and financial benefits may be available, the integration of contract responsibilities with the academic objectives of graduate study requires a full appreciation of the dual aspect of this addition to the academic scene.

Extended service in the form of night schools, off-campus courses, and centers remote from the main campus is a rapidly expanding feature of graduate engineering education. The demand derives both from the employed engineer and from the employer because the rapid introduction of new areas of science and of new methods of analysis and development calls for a substantial supplementation of engineering training. At the present time, the largest number of graduate students in engineering are enrolled in such extended service programs, and the schools with the largest graduate enrollments operate primarily in this manner.

Graduate Program Objectives

The objectives of a graduate program in engineering may be considered in their relation to three aspects: education, research, and service.

Education. The education of a graduate student in engineering should provide means whereby he can advance his knowledge and understanding of the physical sciences and the fundamental principles of engineering. By study and research he should be trained and encouraged to acquire a background whereby he can develop new and improved technological skills and practices in the analysis, synthesis, and design of engineering systems. These objectives receive varying degrees of emphasis to the extent that graduate programs range from those verging on the purely scientific to those concerned primarily with the essential engineering problem of economic design wherein synthesis, judgment, compromise and feasibility are the predominant factors. It is important for the engineer completing graduate studies to appreciate not only the scientific basis of his field, but also the primary engineering characteristic of the utilization of knowledge for practical ends.

Generally, the engineer seeking advanced knowledge in design practice has obtained this from experience or specialized training in industry. While this is sufficient in many cases, it tends to overemphasize the specific applications for a certain industry and neglect the development of the general method. The practice of engineering has become so highly involved that there is a substantial area of general coordination of procedures and approaches to system synthesis and design that might well lie within the domain of educational introduction at the graduate level.

Nevertheless, it is necessary to avoid too close an involvement with specific applications as ends in themselves in view of the danger of finding the scope of the program limited by special interests. There are many situations in industry and government where it

would be convenient for the educational institution to be served with a set of specifications for a graduate program design to meet limited-purpose needs. If a graduate program were organized in this pattern, one would be inviting requests and pressures from a multitude of special-interest groups.

Research. The educational objectives of graduate study cannot be separated from the research aspect of the program. The advancement of knowledge and understanding which critical and creative research provides contributes not only in an essential manner to the educational processes but also furthers the growth of engineering as an academic discipline and the extension of information which may be used as a background for engineering practice. Adequate provision for research by staff and students is an essential requirement for a strong graduate program. This must be supported at the outset as well as continuously by the institution. However, a properly administered sponsored research operation may substantially increase the level and opportunity of the academic research endeavors. Problems which arise in relation to sponsored research in many cases derive from a neglect of the primary educational objectives of the institution.

Service. The third aspect of graduate study is service. No educational institution could justify its existence or exist significantly if it did not have concern for the service it provides. However, education in the academic sense is not altogether a commodity to be determined exclusively by the demands of the consumer. Thus a graduate program in engineering must preserve educational values and maintain standards of professional excellence at the same time that it adjusts to the changing scene in engineering practice and in the utilization of engineers. The objective of service in the graduate program is to meet the needs of the student and the profession primarily with regard to educational facilities and technical comprehensiveness of the program. It is desirable that change in operational practices in the educational program and introduction of new subject matter be accepted and encouraged in the development of effective engineering graduate programs. The extent to which such flexibility is possible will depend largely on related policies and circumstances of specific educational institutions.

The Integrity and Quality of Graduate Study

The maintenance of high standards of operation and performance is a responsibility that basically belongs to the individual educational institutions and in most cases is carefully guarded for all levels of academic endeavor. Nevertheless it has become common practice to impose certain controls for the general protection of the public, the academic community, and the various professions. The administration of these controls usually takes the form of some type of accreditation conducted either by an association of the schools themselves or by a group representing one of the professions.

The acceptance of these controls is a consequence of the practical necessity of assigning a recognized meaning to various certifications. The basic academic accreditation by the schools themselves in the several regional associations (and in some cases by professional groups such as the American Chemical Society, for example) makes it possible for any school to accept students from other schools for further studies on either the graduate or undergraduate level. Without some common basis of evaluation, each school would be obliged to set up its

own rating of other schools from which students might transfer.

With the increasing development of graduate programs both in extent and diversity, the question has been raised of a possible need for an accrediting procedure to protect the integrity and quality of engineering education at this level. Although graduate study in engineering is becoming more and more recognized as an important asset in professional advancement, it is not yet universally necessary, nor is a graduate degree an essential step in securing a professional engineering license. Therefore, it has seemed adequate to let the high standards of each institution control the quality of its own graduate engineering program.

However, the rapid growth of varied patterns of extended service, together with the increasing range and complexity of engineering knowledge, suggest that some general criteria for the graduate programs be set forth. Engineering education, even at the graduate level, has such direct associations with practice that it cannot afford the privileges of complete academic independence. It would be intended that these be used primarily as a standard against which any one institution might measure its own policies and actions and should in no other sense be a means of imposing outside control.

Criteria for Graduate Degree Programs in Engineering

The objectives of graduate study leading to an advanced degree in engineering are to provide the opportunity for the student to reach a critical understanding of the basic scientific and engineering principles underlying his field of interest, and, through training in advanced methods of analysis, research, and synthesis, to cultivate his ability to apply these principles creatively. The areas of interest should include not only the sciences underlying engineering but also new applications in engineering planning and design. In order to attain these objectives, the following principles are presented as standards of good practice in developing and maintaining a graduate degree program.

1. It is the inherent responsibility of the educational institution alone to determine the specific nature and content of the program. The institution has the obligation to maintain high standards and ensure adequate facilities and financing for the program.

2. An exceptionally qualified faculty is essential for a graduate program. The faculty should include a strong nucleus of full-time staff members who have broad experience and recognized stature in all the pertinent areas of study, an established record of professional achievement and scholarly productivity, and the ability to teach and inspire graduate students. The faculty should be constantly alert to developments in its various technical fields and have the capacity for continuing academic and professional growth.

3. Special precautions should be taken to ensure the educational value and integrity of a graduate degree program whatever may be its pattern and regardless of whether on or off campus. The following guides to good practice are given as examples:

a. Degree programs or courses should be established on the basis of considered planning by the faculty and the institution.

b. Compromises in standards should not be made for the convenience of serving some special group or situation.

c. Admission standards should be

(1) established by the faculty,

(2) consistent with the educational objectives of the institution, and

(3) under the direct control of the institution.

d. Part-time teachers from industry or other sources should be integrated with the full-time faculty and participate in the usual faculty functions in addition to their actual classroom teaching.

e. The academic program should be so planned with regard to its scope, variety of courses, and period for completion as to ensure proper continuity and educational value.

f. The educational facilities and institutional resources should be adequate to maintain the highest standards of instruction and to achieve the educational objectives.

g. For institutions conducting undergraduate curricula in engineering, the accreditation of the related undergraduate curricula should be secured before a graduate program is established.

III. MOTIVATION FOR GRADUATE STUDY IN ENGINEERING

Demand and Supply of Engineers with Advanced Training

In the world of today the latest discoveries and findings of scientists are more rapidly than ever before passing from the embryonic-idea stage to the stage of development and practical use. Stimulated in part by the pressure of national defense and security needs, and partially by competitive and economic factors, our technological society is making new and striking advances in a wide variety of engineering fields, such as aviation, electronics, nucleonics, and materials. The solution of the many complex problems encountered today in these and other engineering fields requires a thorough knowledge of many disciplines, particularly of the physical sciences and mathematics. It is too much to expect that students with only the usual four-year engineering training leading to a B.S. degree have this knowledge and competence and hence there is an increasing need and an increasing demand for engineers with graduate training.

These demands are not new, but they appear to be growing more intense. They have been strongly felt for at least the last five years. There is keen competition between industrial companies, the government, and the universities for those students who have taken the time to acquire graduate degrees. Industrial starting salaries for engineers with graduate degrees are substantially higher than for holders of the Bachelor's degree.

The demand for engineers with advanced degrees cannot be met with the present supply. The records show that for the 7-year period ending in 1957, only about 590 Ph.D.'s were awarded per year in all engineering fields. The colleges and universities alone could probably absorb this entire output just for teachers of engineering. But these men are urgently needed also by industry and by government.

At the Ph.D. level particularly, the problems of increasing the supply of engineers are difficult ones. The educational program for the doctorate makes considerably more intellectual demands upon the student than does undergraduate work. More self-study and individual initiative are required, as is also an independent thesis or dissertation calling for original investigative work leading to new contributions to knowledge. Even for students able to go full time, it takes at least three more years of continuous study and hard work. Probably at best only a small percentage of the Bachelor

students are sufficiently capable and determined to profit by advanced study leading to an engineering doctorate. Of this limited group, many are financially unable to continue their studies beyond the Bachelor's level.

Still others are attracted by the inducements of industry, which, because of the severe shortage of engineers and scientists, not only offers higher and higher starting salaries but also promises other attractive advantages such as various types of cooperative educational plans. Such programs may be very helpful in giving the newly-employed engineering student the opportunity for further professional growth and development, but they are not, for the most part, conducive to the acquisition of doctorates. Hence, unless both motivation and financial opportunities for full-time graduate study are greatly improved, the shortage of engineers and scientists at the Ph.D. level will not abate but will increase in magnitude.

At the Master's level the situation is somewhat different. The number of M.S. degrees in all fields of engineering has risen each year from a 1953 low of 3,726 to a 1957 figure of 5,203. On the basis of either a one- or two-year time interval, this number represents approximately twenty-five per cent of the number of B. S. degrees awarded. Thus, already one out of every four Bachelor students in engineering does continue on to a Master's degree. This is about double the pre-war figure and is a result largely of the increased opportunities provided for employed engineers to continue their formal educational program. Most of our urban colleges and universities do now provide opportunities in evenings, late afternoons and on Saturdays for formal course work leading to an M.S. degree in engineering.

However, the need of our complex technology for engineers with additional professional training beyond the Bachelor's degree is so great that the pressure for part-time, evening, and off-campus instruction leading to a Master's degree will undoubtedly continue to increase. It is essential that our engineering colleges and universities respond to this need, but they shoud insist on adequate facilities, competent staff, resident faculty participation and control, and academic environment (see Part V). It should also be made clear that the need can frequently be met in a more satisfactory fashion by full-time resident instruction if proper motivation and adequate financial support in the form of fellowships, assistantships, grants, and loans is available.

Nature of Graduate Programs

Our concern in this phase of the report on Graduate Studies is with motivation; i.e., with those factors or conditions which motivate a student to undertake graduate instruction and training. It is, therefore, essential to delineate the nature and patterns of graduate training that now exist in the field of engineering. This topic will receive considerably more attention in other sections of this report, but it is sufficient here to recognize two important distinctions, that between a more or less terminal professionally-oriented Master's program and a research-oriented Ph.D degree program, and, secondly, that between a more or less resident full-time program and a resident or non-resident part-time program.

The conventional graduate engineering program has been patterned after those existing in other phases of graduate study such as the physical sciences. The requirements for the Master's degree are usually one full-time year of resident study with greatest emphasis placed on one major field and reduced emphasis on one or more

minor fields. Instruction is largely through formal courses, although a Master's thesis involving some phase of independent study is frequently required.

For the Ph.D. degree the corresponding period of time is usually three years of resident full-time study, or two years beyond the Master's. The candidate is required to demonstrate, through formal examinations, a thorough understanding of the fundamentals and major aspects of his chosen field and a reading knowledge of one or more foreign languages. However, the Ph.D. is essentially a research degree and a thesis is an absolute requirement. The equivalent of one year or more is usually spent on independent research work of either an experimental or theoretical character. The doctoral thesis is meant to be a contribution to knowledge and as such it is usually published in the technical journals.

The traditional academic program whereby a student devotes all of his time to study is clearly the quickest path to an advanced degree and one which develops his full potential as early as possible. Such a program is in the student's interest as well as in the interests of industry and of the nation. Active participation in a community of scholars, usually only possible when the student is present on essentially a full-time basis, is itself inspirational and, through cross-fertilization of ideas, does much to stimulate the imagination and encourage individual creativity. Whether the program be one year, leading to the conventional M.S. degree, or whether it be three years, with strong emphasis on a research thesis leading to the Ph.D. degree, the student's talents, ability, advanced knowledge and competence are available to industry and to society in the shortest possible time.

Unfortunately, the advantages of a full-time graduate program are not always clearly enough understood by the students or even the engineering faculty. Even the most competent and talented undergraduate students are frequently not motivated toward nor properly advised about full-time graduate study. Instead, they are enticed by the attractive "earn-while-you-learn" opportunities that are set before them by industrial recruiters. Many of the engineering students have had a difficult financial struggle for four years. When they are confronted with the opportunity of earning an excellent salary and at the same time being permitted to attend a college on a part-time basis to pursue a Master's degree, it is difficult to decline the attractive offer, even though they may also have been offered a full-time study fellowship at a university.

Thus combination education-work plans are actually in some instances demotivating influences toward full-time graduate study at the same time that they are frequently significant motivating influences toward part-time study. For one who could not otherwise go to graduate school, they are clearly beneficial. In fact, a very high proportion of the Master's degrees in engineering are given to employed engineers who go to school on only a part-time basis.

These combination industrial-educational work plans are not nearly as conducive to the acquisition of the Ph.D. as to the Master's degree. The nature of the Ph.D. program is such that full-time activity with continued and persistent concentration on the problem at hand is highly beneficial. Such concentration on study and thesis is almost impossible when simultaneously holding a responsible position with industry. Unfortunately, the students do not realize at the time they are first offered the opportunity

to partake in one of these attractive "earn-while-you-learn" programs that acceptance of such offers may be genuinely prejudicial to their ever completing an engineering Ph.D. The reason the cooperative programs work much better for the M.S. than the Ph.D. is because the M.S. is, as noted earlier, more a matter of formal courses, whereas the Ph.D., with its strong emphasis on research and self-study, requires, of necessity, a much fuller and more intimate participation with other scholars and a continuous period of concentration and study.

Motives for Undertaking Graduate Study in Engineering

In examining the needs that exist today for well-trained scientists and engineers, much attention has been properly directed to the motivation of talented high school students to carry on college work in science and engineering. The shortages at the graduate level are certainly dependent on this underlying question of basic interest. Even with a sufficient number of undergraduate students there remains the task of leading enough students into graduate work. On the part of the student primary motivations are:

a. The desire for further knowledge and the challenge of advanced degrees.

b. The desire for professional stature and prestige.

c. The desire for financial or competitive advantage.

Desire for Further Knowledge and the Challenge of Advanced Degrees. Although it is rather unlikely that any two individuals undertake graduate study for precisely the same reasons, nevertheless the most important motivating factor, and one which is involved to some extent at least in all the others, is the desire for further intellectual growth and greater understanding. In itself, the desire for additional knowledge need not be a motivating factor for formal graduate study. Learning and self-development through independent study and reading are engaged in by thousands of individual college and high school graduates whose formal education stopped at either of these respective levels. Nevertheless, it is difficult to see how anyone could consider undertaking formal graduate work and doing it successfully unless he too were strongly motivated by a desire for additional knowledge and understanding.

The desire for the advanced degree itself may also be a driving influence. The very fact that graduate education is known to be difficult is also what makes it challenging, and under no circumstances should graduate schools consider lowering their standards on the theory that only in this manner will they be able to increase significantly their enrollments and thus do their part in meeting the great demand for engineers with advanced training. Rather, quality of graduate programs, whether on-campus or off, whether full-time or part-time, whether day or night, should be maintained rigidly.

Desire for Professional Stature and Prestige. An important motivating factor is the desire to achieve professional stature and prestige in some engineering field. In engineering, while it is not essential to have an advanced degree to practice, for many engineering careers advanced education is essential. It is rapidly becoming more and more recognized that as a result of the tremendous strides which have been made recently in areas such as electronics, communications, aviation, and nuclear science it is absolutely essential for engineers who wish to be professional leaders in their field to

secure graduate training, particularly with emphasis on the fundamentals of physics, engineering science, and analysis.

An advanced degree is also now generally recognized as essential for anyone planning or hoping to make a career in the teaching or research field, whether at a university or in an industrial or federal research laboratory. Although many capable engineering educators do not now have advanced degrees, it is becoming more and more essential to have a graduate education if an individual wishes to become a member of a college or university faculty and to progress in his respective areas. It is not the degree in itself which is important, but the dynamic viewpoint and specialized knowledge of people who have taken these degrees that is significant.

Desire for Financial or Competitive Advantage. Graduate study in engineering is certainly not undertaken because of immediate financial gain, yet future financial gain may be a very important consideration for some students. The student who proceeds to a Ph.D. degree has a real competitive advantage, because of his additional education, despite the loss of three or four years of job experience compared to a Bachelor student. It is not at all unusual for a Ph.D. student to start his employment in a more responsible and higher salaried position.

Recommendations for Strengthening Motivating Factors

One of the fundamental purposes of our educational program is to develop in the student an intense desire for learning and knowledge and for continued self-development. Without such an urge the student will profit little by graduate study and will probably not choose it even if ample opportunities are available. It is the responsibility of educators and of all people interested in our nation's technical and scientific advancement to help create and maintain the scholarly atmosphere in which the desire to learn is never stifled but allowed to develop and grow. Individuals, departments, colleges, industry, government, national professional societies, all have a responsibility in this matter. Some of the ways and means in which each group can do its part to improve motivation for graduate study are given below.

Contributions from Individual Faculty Members. Each individual college teacher or supervisor should realize that he has a personal responsibility, and that it is his proper concern, to see that the latent talent of his students is developed fully. It should, therefore, be his avowed purpose to stimulate and inspire his students—through courses, lectures, and other contacts—to seek even greater understanding of their major field, of natural phenomena in particular, and of the world about them in general. The importance of an individual teacher to a student's growth cannot be overrated. Many people who have acquired graduate degrees in engineering and science despite serious obstacles were inspired to do so largely because of the influence of some particular teacher.

Contributions from Departments and Colleges. The most important task for the departments in which the student is enrolled—as well as the college as a whole—is to create and maintain in their undergraduate programs the environment in which scholarship and desire for learning flourish. If this environment is one in which progress is evident and creative and imaginative thinking encouraged, the effect on the student is certain to be considerably better than in institutions where the program is standard-

ized, the teaching is uninspired, and undue emphasis is placed on social and athletic prowess. The very fact that certain undergraduate schools, sometimes comparatively small ones, will continually send a much larger percentage of their students on to graduate work than the average for the country as a whole, emphasizes the significant effect of environment on the development of the desire for graduate study.

In order to obtain and maintain the necessary scholarly atmosphere, the most important responsibility of departmental and administrative officials is to select, obtain, and keep on their teaching staff inspiring and stimulating faculty. If the faculty are not themselves alive, enthusiastic, and progressive, one can hardly expect the students to be very different.

Other measures, aside from the acquisition of a capable faculty, which have been utilized with some success to create a favorable atmosphere for instilling in students a desire for further knowledge and study include:

1. The use of selected upperclass students as undergraduate laboratory or research assistants and as aides to senior engineering teachers or research supervisors. In this way, undergraduate students may be brought directly into more personal contact with graduate students and staff members and so learn and profit by this association.

2. Interviewing each student whose scholastic accomplishments give an indication that he could profit by graduate study, and providing him with information and encouragement to pursue graduate programs. This counseling on graduate work should occur very early in the student's career; it should also be continued periodically throughout his four-year program.

3. Encouraging undergraduate students to attend graduate seminars and colloquia, and to take special courses which stress independent study and experimentation in their senior year.

4. Establishing a unified faculty, most of whose members teach both undergraduate and graduate courses.

5. Taking special care to see that capable students who are willing to consider a graduate career, but who do not have the finances to continue, are made aware of all possible forms of fellowships, and of teaching and research assistantships at local, state, and national levels which provide the opportunity for a graduate education at the same time that they give some financial remuneration.

Contribution from Industry. Industry can make an important contribution both in creating the atmosphere in which scholarship can flourish and in providing opportunities for continued education. One excellent means is the establishment of undergraduate scholarships and graduate fellowships to permit talented students who otherwise could not afford to take full-time study programs to do so. Another means is to provide summer work opportunities, particularly in design, development, and research laboratories where the student comes directly into contact with a supervisor who may well be an inspiring and dedicated scientist or engineer. In such circumstances the supervisor may well play as significant a role in motivation as the student's teacher. Direct contact of the student with the latest advances and current research thinking is also stimulating in itself, and should develop in him a desire for and an appreciation of graduate training.

Industrial recruiters also play an important part. Many representatives of both large and small industries contact the student in his senior year in an endeavor to acquire the best possible technical talent for their own

companies. In all instances, they can see that an immediate need will be met by inducing the better student to accept one of their offers. Yet at the same time, they should also recognize that if they draw away too many of the top-notch students there will be very few with advanced degrees for them to employ several years later.

They should, in fact, strongly urge the pursuit of immediate and full-time graduate training whenever the student concerned clearly possesses the necessary qualifications to carry on graduate study, and when financial resources are available. Some of the larger companies do this now, but the practice is by no means universal and in many instances the immediate position is painted in much rosier colors than the more distant advanced degrees.

Contribution from the Federal Government. The National Government frequently plays an important part in determining whether or not capable engineering students go on to graduate work. First of all, through the offering of fellowships, as well as research assistantships on sponsored research projects, it is taking positive steps to permit undergraduate students to continue to take advanced training. The increase in number of engineering doctorates this last year is partially at least the result of the many full-time fellowships for graduate study offered by the National Science Foundation to students of engineering and applied science.

In the needs of our military services, there is a negative factor at work. All healthy students are subject to the draft, and after being deferred for three or four years to complete their undergraduate education, some of the talented students who have the capabilities and should go on to graduate work do not do so. They decide instead that, rather than request initial deferment and then periodically seek additional deferments while pursuing graduate work, they will go directly into the services and fulfill their two-year requirement.

Fortunately, both the Armed Services and the Selective Service Boards have become aware of the national need to develop the full capabilities of all our scientific manpower and hence, for the most part, students are not now required to forego graduate work and enter military service. They are required, however, to renew their deferment each year and there is no guarantee that, even if a temporary deferment is granted, the necessary continued sequence of deferments will be given. Usually, however, deferments are granted as long as the student is proceeding toward his degree on an essentially full-time basis.

The present situation might be improved somewhat if the Armed Services and the Selective Service Boards would grant the talented student who wishes to do graduate work one deferment extending for the entire period of study until his degree is received. It would also be helpful if a similar policy would apply to engineering majors who have taken advanced ROTC. When these students can clearly profit by graduate training and thereby aid materially toward increasing the nation's vitally-needed skilled scientific manpower, the Armed Services themselves should encourage them to go to graduate school.

Contribution from National Engineering Societies. Since the student pondering the problem of whether to undertake graduate study or not has before him all the inducements which an industrial recruiter can provide, such as high salary, rapid promotions, cooperative educational opportunities, and so on, it is also essential that he have before him the relative advantages of staying on at college and

working full-time for an advanced degree. While individual teachers and counselors are perhaps most important in this connection, it would also be helpful if there were available an attractive booklet on graduate work.

This should give all the necessary information that a student would like to know about graduate work before making his final decision as to whether to undertake it or not. The pamphlet should discuss the nature of graduate study, the requirements of the various advanced degrees, the prospects for employment of engineers with M.S. and Ph.D. degrees, and the importance and general advantages of graduate training in providing both a greater breadth and depth of knowledge, as well as intensive experience in research. Such a booklet might properly be prepared by the ECPD or some engineering society. It should, however, be written directly for the undergraduate student and be made readily available to all college or university students, as well as to college faculties and industrial and governmental personnel.

IV. FINANCING

The Financial Problems and Their Solution

Graduate engineering education involves a large investment of wealth, both by society in maintaining competent institutions of higher education, and by the student, his parents, or his sponsors. A full-time, resident graduate student must invest a large share of his earning capabilities for from one to two years to achieve the Master's degree or for from three to four years for the doctorate. Thus financial considerations as they relate both to student and to institution are essential aspects of graduate study.

A greatly increased number of engineers educated beyond the Bachelor's degree will be necessary in the future. If this is to be achieved, graduate education must be financially attractive to the more capable students, and universities and engineering colleges must somehow find the financial means to provide the necessary facilities and instruction. Because of the rapidly mounting demand for increased service in the field of undergraduate education, institutions of higher learning can expect to find extreme difficulty in procuring the financial means to do an adequate job of graduate education. Likewise, supply and demand will place increasing financial inducement for more capable young engineers to enter industry at the Bachelor's level. Society requires a supply of better-educated engineers. The matter, therefore, is one of public concern.

The economy requires more Ph.D. degrees (1) to staff the universities and (2) to fill industry's needs in research and development. The present need is two to three times present production.

Major questions regarding finances are the determination of costs, the financial problems encountered by both students and institutions, and the possible means at hand or to be developed to solve them.

This section of the report is intended to provide some general guidelines for institutions contemplating beginning, modifying, or expanding graduate school facilities. Because of the variety of problems peculiar to each institution and because of the basic differences between publicly and privately supported institutions, such guidelines will be broad in na-

ture and, in the main, applicable to all situations.

Institutional Approaches to the Determination of Costs

The nature and purpose of educational institutions have led them to develop methods of cost accounting which differ substantially from those in business and which do not readily permit separate determination and allocation of costs for various areas and operations. This occurs because of the expanded scope of overlapping and related activities found in the modern university. No single method of cost accounting can satisfy all institutions, as they each have unique problems. Some extensive cost studies have been made, but it is not yet clear to what extent working guides to costs of graduate studies can be provided.

The most useful approach in cost determination is basically that which leads to information for a well defined program, one for which the institution has carefully identified those features necessary to the achievement of its educational aims. All programs need to be defined in this way whether they are in the process of starting or expansion, or whether a comparison with other programs is desired.

Essentially, those features common to all graduate activities and basic to an approach to the determination of costs are:

Faculty and Academic Administration. In determining faculty and academic administration costs, institutions must consider full-time, adjunct, purely graduate, and mixed graduate and undergraduate faculty relationships. Full-time purely graduate school staff, for example, is common in some schools, whereas others may employ adjunct professors to satisfy faculty requirements. The latter occurs, as a rule, when extensive evening sessions alleviate overloading of permanent faculty. Some institutions have faculty teaching both graduate and undergraduate courses, which fact makes more complex graduate faculty cost determination. Fundamental to faculty and administrative staffing is the requirement that attractive salaries be paid to insure staff of quality whether it be permanent campus staff or adjunct staff from industry.

General Administrative and Clerical Assistance. General administrative and clerical costs are fixed costs subject chiefly to the vagaries of standard salary increases and expansion of programs. The major consideration here is one of administrative control in providing adequate support to carry out the operational detail of a graduate program for the academic administration and faculty.

Educational Facilities and Equipment. Facilities and equipment will vary with the educational aims of the institution. A highly theoretical graduate program, for example, may require less and different equipment and facilities than one which emphasizes a high degree of application studies. Some universities may have a problem of "shared costs" between departments or colleges in such areas as shop facilities which by definition furnish services to several operations on campus. The problem is increased further in the determination of shop costs for the graduate program. Similar problems in utilities' costs arise in classroom areas common to several operations on campus.

Maintenance of Physical Plant. Plant maintenance costs vary widely for several reasons: (1) geographical (cost and availability of labor), (2) condition of plant at time it was received by the institution, and (3) varying amortization costs because of geography, initial condition of building, and degree of care exercised in

the plant. The maintenance of physical plant is a factor which only the individual institution can determine and defies universal-type studies, for each university's problem will be peculiar to itself.

The latitude, intent, and short-range and longe-range educational aims and objectives of a graduate program are both of initial and conclusive consideration to this problem of costs. An institution must first know the intention, scope, and hoped for results and then make its plans with the accompanying cost involvements in areas (1) through (4) above.

Once it can be reasonably calculated what the approaches to the determination of costs are within the four suggested categories, an institution can begin to measure the total cost of its program. Until extensive cost studies are organized in a consistent form, institutions must determine their own costs, peculiar to their particular operations, within a workable framework. The overall determinant is the pattern of the program.

Direct Institutional Support

Many forms of financial support are available for educational institutions offering graduate work and most of these possibilities are available to those offering graduate work in engineering. Thus problems of financing engineering graduate work are basically no different than for general graduate education.

University administrators, therefore, are faced with meeting graduate engineering education costs through income from the following sources:

Tuition and Fees. Usually provided by the student or a subsidizing agency in behalf of the student, tuition and fee charges comprise at best fractional instruction costs. Tuition charges for graduate programs, where cost per student-credit-hour is much higher than in undergraduate programs, are not ordinarily increased. Graduate programs tend to reduce the share of tuition revenues which may be devoted to undergraduate work and tend in some areas to be subsidized by undergraduate income. While the problem has not been acute where the graduate program has been small, graduate activities at many schools currently approach or even exceed the undergraduate activities in magnitude.

Investments. Private sources of financial support include income from endowments, which income is basically inflexible in nature and cannot meet rising costs. New endowments occur infrequently because the present tax laws offer insufficient relief to a donor.

State Tax Support. Although some educational institutions may enjoy both private and state support, the college of engineering is usually either privately supported or state-supported. There are few cases of dual support, although state institutions may receive private contributions. A state-supported institution differs from a private one in that the largest portion of its support usually comes from appropriations by the legislature or, occasionally, from specific state revenues. Legislatures have not often made special provisions for the support of graduate work; their primary concern has been to provide undergraduate facilities. There has been little direct support for research by the university in science and engineering. Thus, the problem of providing for the increased cost of graduate instruction and research in state institutions possesses many of the same difficulties as the corresponding problem in private institutions.

Federal Tax Support. Of growing importance has been federal support for both private and public institu-

tions, but such funds have not been supplied to any extent directly for the support of graduate education. The principal federal contributions have been toward the support of research, through sponsored research projects, by many agencies in addition to contributions made for many years to land-grant institutions.

More recently, some federal programs have provided federal funds for the establishment of needed facilities on a matching basis with state or private funds. This use of federal funds is one means of overcoming the physical difficulties. Except for those made available under the Atomic Energy Commission program, these funds have been so limited as to be of little significance.

Contributions. In the absence of sources of endowment today, private institutions are turning more to current gifts to meet operations in the belief that these gifts can and must be maintained and that this use produces the greatest benefit for the income dollar. However, the problem of most institutions is that a large fraction of the income from private sources may be restricted and that unrestricted funds, both endowment and current gifts, are seldom adequate for urgent current needs. Since restricted funds are seldom given for the direct support of graduate work in engineering, the funds for this activity must come from unrestricted endowment funds and unrestricted current gifts. Thus, every private institution has found difficulty in providing desirable and suitable financing of graduate engineering education completely in accordance with the policies and desires of its faculty. There is need to obtain funds specifically for graduate study in engineering from private and industrial sources.

Industry is increasing its direct contribution to education each year, but is still seeking an equitable method for allocating funds to individual institutions, and a basis for selection of participating institutions. Large companies have been able to meet educational requests far more extensively than small companies. Forward-looking industry is willing to underwrite graduate work in engineering on a much broader scale based upon a university's presentation of a well conceived program of its objectives in graduate engineering. The extent of this evidence indicates that the potentialities and implications of such programs should be thoroughly explored in accordance with the basic objectives of institutions of higher learning.

Industry has contributed to institutions of higher education in the following manner:

(a) Aid to education through scholarships, fellowships, and professorships.

(b) Contributions for general operating expenses.

(c) Contributions for the improvement of laboratories.

(d) Contributions toward building funds, specific and general.

(e) Contributions toward specific projects.

Sponsored Research

Research programs are an essential part of a graduate program in engineering. Engineering colleges engaging in extensive graduate programs need to have research funds whose order of magnitude approaches that of funds for instruction. Obtaining and administering such funds, however, poses a major problem for many universities. Funds for engineering research may be provided from the same sources as for graduate instruction: tuition, gifts, or public appropriation. With the increase in instructional costs, these regular sources

of funds are generally found to be quite inadequate, however.

Government Sponsored Research. During and following World War II, important new sources of research funds became available through contract or sponsored research. The principal sources of research contracts has remained the federal government, particularly the Defense Department; however, industries and states have also provided significant funds. There have been some misgivings about contract research largely on the grounds that it tends to be applied rather than basic, and that it may divert manpower and other resources from the academic effort. Most objections on these grounds can be overcome by careful management and contract research will doubtless be an important and necessary part of engineering graduate efforts in the future. An important aspect of contract research management is rather scrupulous cost accounting in order that involuntary diversion of academic resources may be avoided.

Funds for basic research are provided by the National Science Foundation, National Institute of Health, Atomic Energy Commission, Office of Ordnance Research, Office of Naval Research, and Office of Scientific Research (Air Force) through a contract procedure. These funds are not yet sufficient but there are indications that they may be substantially increased.

Starting or expanding a contract research program poses rather great difficulties for many institutions. Sponsorship can usually be found only if the research has already reached an initial stage such that the researcher has developed promising preliminary results and is fully up to date in the field of interest. This means that the institution must usually provide free time from instructional duties, laboratory equipment, and other needs of the researcher at institutional expense, frequently by transfer of what might otherwise be regarded as academic resources. Institutions which have unrestricted gifts or appropriations for engineering experiment stations are fortunate in having available resources which may "seed" a contract research program. An additional source of expense and effort is the preparation of proposals, negotiations, accounting, and other necessary administrative activity. While most institutions can usually make limited transfers in their manpower resources, sufficient to provide the "seed" research, many face a serious problem in providing the buildings and facilities necessary for an effective contract research program. There is the possibility that limited federal matching funds will be provided for this purpose.

Most contract research provides for reimbursement of all direct costs. A percentage is also allowed for indirect costs of administration, physical plant, and other costs common with other institutional activities. Indirect costs should be realistically evaluated by the institution. While allowances of less than full indirect cost may be accepted, institutional management should fully realize the degree of subsidy provided in this case from other institutional resources.

Industry Sponsored Research. Like the federal agencies, but to a lesser degree in numbers of contracts, industry has also supported sponsored research and has generally been quite willing to pay an overhead charge at least as great as that paid by government agencies. Frequently larger overhead allowances are possible because of a realization by industry that the overhead costs allowed by government accounting are inadequate.

Projections. Both government and

industry sponsored research programs have evolved on campus without any unified approach to the basic problems of the universities in this partnership. Industry and government should expect the institutions to provide a cost figure only after they have had the opportunity to review thoroughly their many cost features in accordance with the sponsoring agency's needs and the peculiarities of the particular academic operation. To meet this typical campus problem, universities might request that industry and government consider the following:

1. Matching fund subsidies.
2. Loan provisions for physical facilities which in time pay for themselves.
3. Fellowship programs with additional adequate support as inducements for high caliber students to continue graduate study in specific project areas.

Joint Industry-College Special Purpose Programs

Frequently industrial and government money is available for full reimbursement of special purpose programs. These programs are quite separate from existing programs of graduate study in that they are of short duration rather than of sustained study. They are designed to meet immediate or temporary requirements for advanced engineering knowledge of specific organizations. Even though such programs are for special purposes, educational institutions may possibly integrate them into the more comprehensive programs of graduate study leading to the advanced academic degrees. For institutions which wish to extend their educational services in graduate engineering and which wish to explore additional sources of financial support, this is an area of activity which has not to date been cultivated to any great extent in engineering education.

There is a need for special purpose programs of graduate work in specific fields of engineering. An example is nuclear and reactor engineering, where the pace of the relatively new technology has created a demand for engineering manpower greatly exceeding the foreseeable supply of engineers educated and trained in this specific field. There is a definite need to supplement the efforts of existing schools.

Such efforts are limited only by the particular requirements of industry and engineers in and about the collegiate area, the capabilities, facilities, philosophy and business objectives of the institution involved, and the imaginative effort needed by both to explore and experiment with the possibilities of providing and using the conceivable educational services.

The cost of industry's total financial support of such special purpose programs is as acceptable as any operating charge within a company—there is no question about the principle of cost-bearing for all ramifications of services rendered.

Developing New and Revising Old Means of Financial Support

As a practical matter increased funds for graduate education must come from the previously indicated sources of institutional finance. The problem confronting the graduate schools is how more funds from all sources may be directed into the graduate effort. The cooperative effort of the engineering profession, the graduate schools, and industry is pivotal in the achievement of such aims.

Suggested action in this area follows the following pattern:

1. Industrial contributions could be solicited and handled by regional graduate school associations.
2. Joint professional, graduate, and

industrial teams should present the case to agencies appropriating public funds, philanthropists, and philanthropic organizations.

3. Increased contributions by individuals and industry could probably be induced by providing increased tax benefits.

4. Industry could be requested to increase aid in its several normal spheres of interest. For example, fellowship grants should be increased to a realistic standard to allow adequate additional support to the institution.

The Student's Financial Problem

American society has created a critical educational paradox in forcing the young graduate student of above average talents to operate at an economic level lower than basic costs. There exists real conflict between those forces attempting to motivate him towards graduate study and the facts of life which require him to live at a low standard if he undertakes further study.

When he enters graduate school, the engineering student is likely to undergo rather radical changes in his personal financial point of view. He is probably no longer willing to look for support from his family; he is particularly vulnerable to the urge to start his own family, and he has at his command a vast new earning power and a new, exciting professional capability which he did not have prior to his graduation and which he is enthusiastic about putting to work. While graduate work today may possess demonstrable long-term economic advantages, many students are not willing to gamble on the long-term investment, and thus settle for the short-term gain of immediate employment after the Bachelor's degree.

There are three marked forces at work affecting the graduate student and his family which deserve our particular study:

Increasing Student Families. In 1950 a higher percentage of students were married by the time of first graduation than in 1940 and their families were about 60 per cent larger. These facts have increased the financial problems of many engineering graduates who do plan to continue their education to the M.S. and Ph.D. levels. Sympathetic domestic understanding of dedication to advanced study is required, particularly when unusually high salaries are available elsewhere to competent graduates who qualify for graduate education.

Increasing Cost of Education. The present high cost of education, increasing steadily since World War II, has an inhibiting effect on enrollment in the graduate schools. A recent study stated that of 71 private schools contacted, 44 or 62 per cent stated that they would increase their tuition costs for 1956-57; and of the 48 state schools contacted, 28 or 58 per cent also will increase tuition. No doubt many students will find these and future increases compelling reasons for not beginning or continuing graduate work.

Family Income and Cost of Education. A comparison of the rise of the cost of education with the rise in the earning power of the American wage earner is useful to better understanding financial problems of graduate students. Comparative cost of living and cost of education studies show that over the past ten years a larger number of families of hourly employees have been economically able to send their children to college today than at any time before in the nation's history.

Families where the wage earners are professional persons, whose earnings have lagged and who have traditionally served as the source of the

greatest segment of the college population, find that college education poses an increasing economic burden. Such families now experience serious financial problems in sending their children to college because the cost of education has increased more rapidly than their family earnings. Students from these homes, although interested in graduate study, frequently leave school upon receiving their Bachelor's degrees rather than burden their families with the additional costs necessary for graduate work.

The problem, therefore, is to assist the graduate student realistically in meeting simultaneously the cost of living and the cost of education. If the number of graduate students is to be increased, there must be enough support to keep them at a subsistence level without additional outside aid from the family. Otherwise the number needed will not be obtained.

Financial Support for the Student

The pattern of financial support for graduate students is complex and diverse. It has become so extensive as to represent a dominant factor in the development of graduate programs. There are four major sources available to the graduate student for his support:

Personal and Family. A negligible number of students are supporting themselves in graduate study through personal funds; and graduate students, as a group, are loath to request assistance from their families who may have borne in some part the expenses of their undergraduate education. To assist families in meeting this continued cost, there is real need for realistic interest rates for loans and for equally realistic tax relief in this contribution to education.

University. University funds for support of students have always been limited. Any attempt to enlarge this support will bring a direct increase in costs. The extent to which such increases can be accommodated represents a basic consideration in financial policy.

Traditionally university funds are available in the following areas:

1. Student loans which are usually low in principal, difficult to obtain, and are unpopular because of the moral obligation to repay during employment soon after graduate study has been completed.
2. Fellowships which are considered as financial sponsorship involving research or study under which the student has no obligation for a particular piece of research or for a specific program. Usually, however, the general area of activity is specified.
3. Scholarships which are less restricted than fellowships and may range from tuition scholarships to grants of funds sufficient to provide for subsistence and other expenses.
4. Assistantships in which the student renders part-time service to the institution in teaching or research for which he receives regular pay.
5. Part-time teaching.
6. Part-time research.

Government-Sponsored Research and Summer Employment. Although a few graduate assistants were assigned to sponsored research prior to and during World War II, extensive programs in this area did not develop until the close of the war. The Department of Defense is responsible for the major share of activity in this program. The establishment of the Office of Naval Research was a major factor in the evolution of sponsored research under the Defense Department. This was followed by similar programs by other Defense Agencies, the Atomic Energy Commission and the National Science Foundation. Presently such research is sponsored by a great many federal agencies in

most of the federal departments. Ordinarily a University or Research Foundation presents a proposal to the agency to conduct certain specified research. With approval of the project, funds are allocated to cover all or part of the expenses of the work, which funds would include the sponsorship of graduate students in research areas.

Federal agencies, particularly those of the Department of Defense, make available summer positions in many areas of engineering and scientific specialty.

Industry. Industry has long been aware of the economic problems in the personal development of the graduate student. Whereas much support has been given him indirectly through grants for professorships and laboratory equipment, he has for many years received industrial assistance directly through the following means:

1. Fellowships, which have achieved three forms.
   a. Full-study fellowships in which the recipient was selected by the university among its regular applicants.
   b. Special purpose fellowships for employees in combined work-study advanced degree programs.
   c. Sponsored research.
2. Tuition assistance or scholarship for employes in after-hour graduate programs.
3. Summer employment.

A Forward Look

Because of the attractive salaries recently available to engineering scientists at the Ph.D. level, there is an increased incentive for more B.S. graduates to push on to graduate work. Recent studies have shown that the starting salary for Ph.D. graduates may be from about 10 to 30 per cent higher than for B.S. graduates—the very high salaries going to the most capable graduates. The rate of rise of these salaries after employment, however, is not so great as for the B.S. graduates.

If economic and world conditions remain as they are at present, there is a good prospect that the average life-span earnings of Ph.D. holders will increase considerably. If assured of such income, a great many more engineering students would be inclined to make the sacrifice necessary to send themselves through the Doctor's program. While there is hope that such a development may ultimately solve the manpower shortage at the graduate levels, a history of stable economic advantage of sufficient length as to become almost traditional may be necessary before a sufficient number of high-quality students will be willing to invest the time and effort. In the meantime, expansion of fellowship, scholarship, and assistantship opportunities at the universities with adequate stipends is very important in maintaining the flow of highly intelligent engineers into graduate work.

V. PATTERNS OF GRADUATE STUDY

Evolution of Patterns of Graduate Study

Diverse patterns of graduate study in engineering have been developing and expanding since the late '30's when sizable numbers of practicing engineers with only Bachelor's degrees began to find it necessary and desirable to pursue courses of study of a more advanced fundamental nature.

One of the first developments was that of part-time graduate study in the larger metropolitan communities where concentrations of practicing

engineers and ready transportation facilities made it possible to bring groups from various fields of practice together each week for regular classes.

As the practice of engineering advanced in many complex technical fields during the next two decades, the demand for individual courses at the graduate level and for complete degree programs of graduate study on a part-time basis also increased.

In the late '40's a large number of men with educational benefits from military service swelled the ranks of those pursuing various patterns of graduate courses and brought into such study many who otherwise might not have undertaken graduate work.

With the growth of sponsored programs in university research institutes, an increasing number of graduate students have been engaged on-campus in combination work and study programs. Many of these campus arrangements closely parallel the conditions of part-time graduate study and industrial employment.

Where the concentration of potential graduate students is separated geographically from a university campus, entirely new and novel arrangements for off-campus courses and off-campus study centers have evolved.

Recent expansion of the application of engineering sciences in industrial activity on a broad front has required greater numbers of professionally trained personnel. At the same time the level of education required has advanced. This conflict between the need for personnel and the need for persons with advanced education has given rise to many plans for concurrent practice and advanced study, arranged particularly for the recent graduate.

Most of these diverse patterns of graduate study have proved effective and productive. They have made significant contributions to the general advance of engineering education. At the same time some patterns have presented a number of new problems. Also, some old problems have been accentuated. To identify and study these problems is the purpose of this section of the report.

Criteria for Evaluating Graduate Study Patterns

As a first step in such a study it should be recognized that under all patterns of graduate study there must be common agreement on ultimate objectives, content, and standards of performance. Although the approach to these goals in specific instances may be along somewhat different lines and under more or less difficult circumstances, there can be only one set of criteria for evaluating graduate study, regardless of the pattern under which it is offered.

It is apparent that a number of different patterns of graduate study are now well established and that several of these undoubtedly will continue to be an important part of the future in the engineering education framework.

It is the purpose of this section, therefore, to describe acceptable criteria and to discuss how the challenges of unique situations may be met.

Graduate Study Defined. The term "graduate study" as used herein refers only to study in programs acceptable for credit toward advanced degrees in engineering majors.

A further distinguishing characteristic is that graduate study, under whatever pattern it is offered, represents much more than the development at advanced levels of topics previously introduced at the undergraduate level. Graduate study is characterized by a considerable advance, not only in subject matter but even more so, in a scholarly attitude

toward the subject matter on the part both of the teacher and of the student.

Since there are many types of educational programs which may be considered desirable for the professional development of the young graduate engineer under the general heading of "continued education," it is necessary to distinguish between the specific field of "graduate study" as defined above and the broader field of "post-baccalaureate" study.

This differentiation is especially imperative in situations where the number of part-time students may be dominant and where a wide range of interests and backgrounds may be rather freely intermingled.

An excellent example of the "post-baccalaureate" type of study is that of courses covering recent developments in related technology or a field of technology not usually covered in the regular undergraduate program. As important as such courses may be, they are generally informational in character, do not require any advance in attitudes or ability to comprehend above that of the undergraduate level, and therefore cannot be considered as graduate study.

Supplementary study in the related fields of liberal arts and business, industrial training programs, courses dealing with specialized practices, and similar educational activities of the non-degree or non-engineering type are likewise to be classified as "post-baccalaureate" study.

Such study is recognized as essential to the general advancement of the profession of engineering but it is not to be included under the term "graduate study" which is the subject of this report.

Neither should graduate study, under whatever pattern it is offered, be classified loosely with "extension" courses of the non-credit type.

Desirable Characteristics of Graduate Study Programs. Before appraising the various patterns which graduate study may take, it is essential to set forth those desirable attributes which are necessary for an effective program and which should characterize any form of graduate study.

Staff. The greatest need is for a strong nucleus of full-time faculty which as a group has: (1) strength in technical and professional competence (2) experience in offering graduate programs, (3) ability as effective teachers, (4) stature as leaders in engineering thought and research, (5) broad social and cultural interests.

A background essentially of practical experience, no matter how strong, cannot in itself be a substitute for the insight into critical understanding and creativity required of a graduate teacher.

Selection of able, informed, and devoted teachers with high standards of achievement is the prime requisite for the quality of teaching and of student performance required in graduate study.

Whenever part-time faculty members are engaged, it should be clearly understood that the teaching obligations are broader than the conduct of classes. As a means of complete assimilation of the part-time staff member, a requirement to participate in selected departmental functions as a working member of the faculty is to be recommended. Consistent with this objective is the plan of compensating adjunct staff on a retainer basis rather than an hourly-fee basis.

When graduate study assignments are superimposed on top of many other duties, great care must be taken to avoid an overloading of staff members. This is as true for full-time staff members with undergraduate teaching, research, consulting and committee work as it is with part-time staff members and their responsibili-

ties of engineering practice. In both cases recognition must be given to the relatively greater amount of time required in all aspects of instruction at the graduate level.

Facilities. Well-designed classrooms, fully equipped for the most advantageous use of all modern teaching techniques are as essential in any pattern of graduate work as in any other educational program. Compromises permitting the use of make-shift or temporary accommodations, especially in off-campus programs, may seriously detract from the effectiveness of instruction.

Since the frequent use of numerous reference materials is as essential in graduate class work as it is in research, adequate library facilities are a basic need for all students. Use of the library well beyond normal class schedule hours should be anticipated and provided for.

Graduate research laboratories, whether for part-time or full-time students, need to be well-equipped, provided with adequate service, and available to all students over long hours.

Availability of industry libraries and laboratory facilities may serve as a supplement to, but not as a substitute for, adequate campus facilities of a sponsoring institution. No college or university may rightfully contemplate graduate study under any pattern without first acquiring appropriate facilities under its own jurisdiction.

Educational Policies. Complete control of the aims, content, conduct, and evaluation of the graduate program is appropriately the direct responsibility of a well-organized faculty composed largely of full-time staff members. Such control is to be retained and exercised vigorously by the faculty regardless of the pattern of graduate study. The initiative to organize, modify, and discontinue programs of graduate study should remain with and be the responsibility solely of the faculty of the sponsoring institution.

Graduate study, under any pattern, logically has its beginning with a complete and adequately supported program of study leading to an advanced degree. The establishment of a series of unrelated courses of advanced study does not in itself constitute the establishment of a graduate program.

In order to provide the maximum opportunity for an intermingling of minds and the cross-fertilization of ideas so necessary to the stimulation of imagination and the encouragement of individual creativity, graduate courses whether on-campus or off-campus should preferably be available to all qualified students of the community.

Closed company courses, as necessary as this arrangement may seem in some instances, are to be recognized as losing many of the potential values of the usual "open" graduate class.

Continued emphasis on the thesis as a requirement for the advanced degree, even at the Master's level, is to be recommended particularly in the case of other than full-time students. Inherent in the thesis requirement is an excellent opportunity to provide for an integration of the student's entire graduate program, to require close association between the student and an adviser, and to test the level of the student's achievement.

Moves toward permitting the substitution merely of additional courses in lieu of a thesis will most certainly make more difficult rather than simplify the efforts to maintain the integrity of graduate study under diverse patterns of offerings.

While research in the quest of new knowledge for the sake of new knowledge has generally been the background of the traditional graduate

thesis requirement, challenging projects of analysis, design and synthesis of new and novel problems are to be recognized as equally acceptable in engineering graduate study.

This type of thesis is frequently more consistent with the professional objectives of many students who have had periods of experience in engineering practice.

Thesis research, especially when permitted off campus, is best directed when prior approval of the project by faculty consultation before work is begun and regular interim reports to a faculty adviser, selected from the full-time staff, are required. At the same time a number of well-qualified associated staff members for supplementary thesis advisory committees can frequently be found amongst advanced degree holders in engineering practice and in research in the community. Off-campus thesis operations, when permitted, should be inspected by the full-time faculty.

Selection of Students. Graduate study is clearly the province of the superior mind. As such it is normally open only to those with better than average scholastic records as a minimum standard. Performance in practice may offset apparent deficiencies in previous scholastic work but the number of such cases can be expected to be limited and the evidence must be convincing.

Since the prime purpose of graduate study is the successful pursuit of a complete program of advanced work, the dominant number in any group would be expected to be degree candidates. Injudicious mixing of auditors and unqualified students with regular graduate students can only lead to an undesirable dilution of effort and results.

There is need, therefore, for distinguishing the truly intellectual from the "interested" student and for dispelling the idea that all persons with a Bachelor's degree can "gain something" from graduate study.

The number of applicants who would be better served by a program of "post-baccalaureate" study rather than by "graduate study" increases where part-time study is available. Counselling services need to be expanded in such situations.

In this respect the employers of engineers have as great a responsibility as the educational institutions. Fortunately, there are as many examples of well-established educational counselling procedures in industry as on college campuses. These services, in fact, may be more generally attuned to the over-all problems of the part-time student. If properly oriented to the problems of selecting graduate students, they may well serve as valuable adjuncts to institutional service.

Student-Faculty Association. Close personal associations between instructors and students and amongst students themselves are recognized as essential elements in every effective educational program. These associations are the heart of the teaching activity and need to extend well beyond the physical bounds of the classroom and laboratory and even beyond the major field of study.

In patterns of graduate study which tend to disrupt these associations, it is necessary to place particular emphasis on compensating mediums such as seminars and departmental conferences. The availability of both faculty and students at established hours other than the normal class periods should be considered a regular part of the educational schedule and graduate study obligation.

When adequately developed, these associations with part-time students from diverse fields of practice may in fact prove a stimulus for and a benefaction to full-time campus study for both students and faculty.

Continuity and Concentration. From an institutional point of view a series of lecture courses alone does not establish a graduate school. A continuing program of advanced design, investigation, and research led by a faculty of distinguished teachers is the cardinal requirement.

Likewise, pursuing a graduate study program from the student point of view must be more than attending a series of courses. A well-defined professional objective and an approved plan for achieving this goal should be a requirement for every graduate student. Provision for meeting certain reasonable criteria for continuity of the graduate program and for periods of concentration on graduate study above all else would seem to be a logical component of such a plan.

In order to preserve a maximum of integration of the various portions of a degree program, a total length of time for degree credit is usually limited to the range between 4 and 7 years.

The graduate student should be made aware of the long hours of preparation required outside of class. Definite arrangements to control loads, to prevent excessive work and study schedules, and to reduce conflict with other obligations are recognized as necessary for optimum growth in graduate work. A limit of 6 credit hours per week is usually imposed as a maximum load for students in after-hours programs.

At least one substantial period of concentration on graduate study, as the major effort of the student, free from the dissipating and diluting effects of other primary responsibilities, is to be strongly recommended.

Patterns of Graduate Study

With the desirable characteristics of a graduate study program outlined as above, it is now possible to analyze the problems presented by the various patterns of graduate study from a fundamental point of view.

Several different analyses may be made using each of the following points of reference:

1. The effect of various patterns on the career planning of the student.
2. The status of the student, whether he is industry based or university based.
3. The plan of faculty and student educational activity.
4. University administrative policies and problems.
5. Industry support for financing graduate education.

Next it becomes necessary to identify the specific patterns of graduate study offerings. This is probably best done on the basis of time schedule arrangements.

Full-time Study. A continuous full-time schedule of educational activity comprising 12-15 credit hours per week until the advanced degree is earned. The major concentration is on graduate study. Employment, if any, is only incidental. Such study is always "on-campus." This plan may be termed the traditional or conventional pattern.

Concurrent Study. Usually a program of courses for which a student devotes a limited number of hours each week to graduate study without interruption of his employment. Such work may be either "on-campus" or "off-campus." Two plans are used:

1. After-hours courses in the evening or late afternoon and on Saturday when the student elects to use his own time for graduate study.
2. Released-time arrangements during normal working hours at the end of the day or during the day, frequently to meet with campus classes of full-time students. In this case the

employer must directly approve of the individual's educational plan.

Another break-down in classification of students pursuing "concurrent study" might depend on whether or not the student is employed on-campus by the University. This distinction is referred to under the discussion of "Residence Requirements."

Interim Study. Courses for which a student interrupts his employment for a designated period to pursue graduate study. These plans are usually "on-campus" and may be either:

1. Cooperative courses in which definite alternating periods of study and practice are scheduled.
2. Leave-of-absence arrangements which provide a complete release from duties with the employer for a specified period usually longer than the cooperative period.

Many institutions encourage those who begin graduate study as part-time students on a concurrent basis to complete the work for the degree by means of full-time or interim periods. Some institutions require registration in at least one full-time period of graduate study before the award of the degree. This is especially true in doctoral programs.

Off-Campus Graduate Study

Recent years have seen a marked growth of requests for off-campus graduate study stemming usually from an industrial or governmental activity remote from any college campus.

The most favorable experience in off-campus work has been at "graduate study centers" where a satellite campus has been developed. In such cases a resident director is usually assigned from the university staff, and classroom, library, and administrative facilities are brought close to par with the main campus counterpart. The controlling majority of faculty in such cases should be recruited from full-time staff and assigned to the "center" for extended periods. The "center" then operates very much in its own right as a small college with the added advantage of a background of valuable experience and resources from the sponsoring institution.

In the absence of an off-campus center, selected courses have frequently been offered at other off-campus locations, such as company premises, local high schools, etc. Most of these arrangements have been considered temporary and the offerings are usually limited to introductory graduate courses.

In general, only a restricted amount of study at off-campus locations, other than at graduate "centers", is accepted in fulfilling the requirements for an advanced degree.

In any case, all of the controls mentioned above as relating to admissions, syllabi, staff, and use of the library, need be applied with the greatest of discretion in off-campus situations.

In view of the greater operational and administrative costs involved, most institutions have found it appropriate and necessary to increase tuition and fees for off-campus study. Off-campus operations are seldom self-sustaining and as such usually require financial support other than that obtainable directly from the students. To insure the proper continuity of off-campus operations, adequate and continuing financial support should therefore be available before such a program is established.

Effects on Career Planning of the Student. For the student who has his objectives well in mind and for whom financing is no problem, there is little doubt but that the continuous uninterrupted educational program offered by the conventional full-time pattern holds many advantages.

On the other hand, the opportunity

to find a place in professional practice or research and to gain valuable experience in the application of their undergraduate education will always be of great assistance in the career orientation of many excellent students.

The stimulation values of concurrent graduate study patterns are not to be underestimated, if a substantial degree of faculty-student association, continuity and concentration on study can be arranged.

Status of the Student. In all cases of concurrent study there is the continual hazard of controlling obligations to authority other than educational. Much of this risk can be removed by understanding and sympathetic supervisors. However, this is a matter which requires much more than top management approval of concurrent study plans. To be successful such programs must have the wholehearted support of the immediate supervisor of the graduate student. Without this understanding, serious interruptions may, and do, occur. Leave-of-absence, cooperative, and released-time arrangements are more likely to have this hazard removed.

Obviously, on-campus employment should also improve the opportunity for continuity of program and association with faculty and with other students, but it does not in itself insure that these desirable characteristics will be better maintained than under conditions of off-campus employment. Continual attention to these matters is necessary.

Faculty-Student Operational Plans. Concurrent work and study plans require that both faculty and students do more than take for granted the adequacy of their association with each other and the value thereof.

While actual check-point systems are seldom used for full-time graduate students, the very presence of such students on the campus is usually taken to insure that the desirable characteristics gained from "residence" are actually being realized. This may not always be so, but it is nevertheless assumed in most cases.

Some more positive means of insuring regular consultation with teachers and advisers should be an integral part of all patterns of graduate study.

A distinct problem in the case of after-hours programs and off-campus released-time courses is that classes may be composed almost exclusively of part-time students. An advantage of the cooperative and leave-of-absence plans is the much greater opportunity for students under these plans to assume the role of full-time students and to benefit from the greatly increased opportunity for faculty-student associations.

Particularly in after-hours sessions and especially at off-campus locations, the tendency of both staff and students to arrive and depart immediately before and after class sessions needs special attention.

University Administrative Policies

Whatever educational and administrative policies are adopted for the proper guidance of graduate study, the paramount objective should be to maintain the integrity of graduate programs by insisting on high standards in: selection of students, course content, assignment of staff, use of library and laboratory facilities, faculty-student and student-to-student associations.

Although it is well recognized that the conditions under which part-time programs are conducted may at times impose extra burdens on staff and students, there can be no basis in these facts for compromise with the objective of high scholarly achievement in the educational program.

Any institution sponsoring concur-

rent type graduate programs must be aware of and willing to assume the additional effort required to maintain standards.

The ability of an institution to sponsor and administer a high caliber on-campus program should be well demonstrated before any off-campus program is undertaken.

Not all institutions can or should endeavor to maintain graduate programs in any or all patterns. Rather each institution might better seek to do that which will render the greatest service to the profession of engineering and at the same time do justice to its own position in the educational spectrum.

It must be recognized that many small colleges have made impressive educational records, not by their own graduate study programs but by the number of students which they have prepared and encouraged to pursue graduate work on other campuses.

Financial Support of Various Patterns

To date financial support of graduate study by industry has been principally in the after-hours pattern where the number of students benefitting is large but the amount of aid per student is somewhat limited. Nevertheless the opportunity for a young engineer to make a start in such a program of graduate study is usually available on a broad basis.

Under cooperative and leave-of-absence patterns a more highly selective process of designating graduate students is used. The financial support by the employer is more complete but is available to a much smaller number of students. The number of such opportunities is growing.

The number of grants directly to universities for graduate scholarships and fellowships has shown only a modest increase in recent years when compared to the sharp increase in graduate student enrollments of all patterns. There is a real need, therefore, for a substantial increase in this type of sponsorship independent of employment commitments.

As mentioned elsewhere in this report, the stipends for scholarships, fellowships, and assistantships must also be increased to make them more attractive to a larger number of outstanding students when compared with competing plans of immediate employment in professional practice.

In short, there is a real need for supporting agencies to finance graduate study on a more general basis and from a long range point of view. Only in this way can a more favorable balance in numbers of students enrolled under each of the various patterns of graduate study be achieved.

The Residence Requirement

Much further consideration needs to be given to the traditional residence requirement. Here an opportunity exists for some careful experimentation in the evaluation of this requirement.

Too often the basic objectives of the residence requirement are lost sight of in the mechanics of administration. The real objectives of this requirement appear to be:

1. To provide for the graduate student the full realization of the advantages of association with a scholarly community.
2. To insure adequate guidance for the graduate student.
3. To permit appropriate evaluation of his accomplishment in the graduate program.

In a broad sense then, the values of "residence" may be found in the total environment in which a student works and studies. If this is so, it may be possible to evaluate the equivalent of residence.

When study is undertaken on a con-

current pattern, occupation in industry may be the student's primary activity, but this occupation may also provide the desired sympathetic and supporting environment. The basic question is whether or not the total environment leads to suitable motivation, whether or not it provides sufficient opportunity for association and communication with other persons pursuing similar scholarly obectives, and whether the accomplishment of the non-resident student can be adequately measured.

There is the further view of "residence" which recognizes education as a "give and take" process. Students are as much a stimulation to the total environment as are faculty. Hence there is the university motive of wanting to have these stimulating minds participating to the greatest possible extent in campus life. In this light it may be recognized that a university grants a degree as much for contributions to academic life as for personal achievement. Individual achievement without participation in university affairs is otherwise recognized by such distinctions as professional licensing and membership in professional societies.

Present Status of Various Patterns

To provide more complete information on the status of various patterns of graduate study, this commission has inaugurated a statistical survey of the principal colleges and universities now conducting graduate programs in engineering. This survey will be revised from time to time and will be available through the office of the Secretary of ASEE.

References. For the convenience of those seeking more detailed information about the conduct of graduate study under one or more of the diverse patterns mentioned above, a selected group of universities have written brief reports indicating how the principles outlined in this section have been implemented on their campuses and in off-campus operations. Copies of this supplementary information will also be available from the office of the Secretary of ASEE.

The feasibility of several acceptable patterns of graduate study in engineering has been clearly demonstrated in recent years. There is no reason to believe, however, that all universities should consider extended service. Many institutions may justifiably limit their activity to the full-time resident pattern. Others with substantial resources and experience may find it desirable to sponsor more than one pattern. But the common objective of all institutions should be a high level of performance, whatever the pattern.

VI. DEVELOPMENT OF GRADUATE FACULTIES IN ENGINEERING

Enrollment Trends

The anticipated enrollment of graduate engineering students during the next fifteen to twenty years necessitates a corresponding increase of faculties.

Data on engineering enrollments through 1956-57 are shown in Table I. It is estimated that the total number of degrees granted in graduate curricula will more than double in the next ten years if the percentage of Bachelors-graduate who take advanced studies remains the same as at present. If the percentage taking graduate studies increases, as seems likely, the graduate enrollment will be even greater. There is no point in

attempting to predict the exact graduate enrollments in the next ten to fifteen years; it is clear that large increases are indicated.

If the enrollment trends in engineering graduate schools are as indicated and if we assume the student-faculty ratio to be constant, then it would appear that a reasonable estimate of the increase in graduate faculty would be from 100 to 175% in the next ten years.

If, on the other hand, present studies to increase the student-faculty ratio in undergraduate schools mitigate the problem of teacher shortages, and if these are extended to graduate schools, the estimates stated above are too high. It does not appear at this time, however, that graduate school activity shows any indications that such changes are apparent for the near future.

The conclusion is inescapable, in any event, that the number of faculty members participating in graduate activities must be increased. The figures given above, of course, are only estimates, but might give a fair indication of the rate of increase that would allow us to meet successfully the demands of the future.

Sources of Supply for a Graduate Faculty

Past and future sources of supply for graduate faculties have been and will be twofold; first, our schools of engineering, and, second, the engineering profession at large. The real problem is how to utilize these sources more fully than in the past. The solution to this problem depends to a large extent on the individual institution and its particular environment. The problem of increasing the graduate staff from the engineering professions is worthy of consideration here. How a graduate faculty is evaluated and what constitutes an adequate background for a graduate faculty must also be reviewed.

Engineers and their employers must be made to realize the value of graduate education. They are in a position to help directly, but need to be convinced that such help is required. Some of the mechanisms for doing this are:

1. Members of the engineering profession well qualified in specialized areas may be persuaded to teach a course on a part-time basis. Such people should not be simply encouraged to teach a single course but should be appointed as part-time faculty members and be required to join in discussions at faculty meetings and seminars. This helps the courses they teach to become an integrated part of the students' plans of study.

2. Employers can be persuaded to hire teachers of graduate work as consultants, thus supplementing their salaries and enabling them to remain full-time instructors.

3. Employers can encourage some of their well-qualified personnel to take a year's leave of absence to be spent at a given institution as temporary members of the graduate faculty.

4. Each individual school should explore ways to supplement its graduate faculty with part-time members. A variety of programs of high quality, depending on the particular environment in which the school exists, could be developed to supplement existing graduate faculties.

Qualifications of a Graduate Faculty

Background. There appears to be general agreement on the over-all qualifications of the ideal engineering teacher who is engaged in graduate instruction. His knowledge of and his ability to handle the subject he teaches must be at least commensurate with the requirements of the specific levels of graduate instruction; he

must have an appreciation of fields allied to his subject; he must have the ability to convey his thoughts clearly to others; he should be capable of inspiring his students toward creative and original thinking; and, finally, his character, personality, and professional bearing should command the respect of his students and associates. This combination of desirable talents is, unfortunately, seldom contained in a single person, thus raising the more realistic question as to what compromises can be accepted at the various levels of graduate instruction without materially affecting the training of students.

In addition, to be truly effective the teacher must enjoy his work. He must be motivated by a sense of responsibility in entering the profession. Good teaching invariably involves some sacrifices on his part. Financial rewards are not high, personal research must often be deferred because of teaching duties, and consulting activities are often handicapped if adequate attention is given to student problems. The teacher must find his compensation by dedicating himself to his important task of training the young—an inner satisfaction far greater in significance than surface annoyances.

Evaluation. Evaluation of professional performance and conduct, and personal ambitions and objectives, intangible as some of these may be, is the obligation of one or more responsible judges. Since these qualities are possessed to a varying degree by individual faculty members, and since a healthy balance becomes a desirable pattern for the students, the following factors seem to have the most importance.

1. The faculty should give indications of continuing academic and professional growth.

2. The faculty should be able to aid students in orienting their plans and interests toward laying a foundation for progressive professional development.

3. The faculty should be able to demonstrate that its interest in teaching induces a loyalty to the profession and the institution, and inculcates a sense of values in the students.

4. The faculty's stature should be enhanced by appropriate industrial association and experience, which it should be able and willing to communicate to the students.

5. Although degrees, publications, and committee leadership in professional societies are indications of solid qualifications, these must not be ends in themselves. Only through an intimate knowledge of the individuals concerned can the attributes of the faculty be established.

In-Service Development of the Graduate Staff

In-service development is a key factor in organizing and holding together a talented group of graduate teachers. Opportunity and encouragement for personal professional development is probably the greatest factor influencing in-service development.

This means that each staff member should find an environment which lends encouragement to his efforts to improve himself professionally. The younger man would find opportunity to increase his knowledge in his area of technical interest by advanced study. It also means opportunity for him to increase his ability as a teacher and to do original thinking in the form of research activities. It should be the objective of every school administration to encourage its young staff to pursue scholarly and professional activities.

The development of younger men into capable graduate teachers re-

quires association with colleagues who have already attained a fairly high degree of prestige, so that a proper atmosphere for encouraging advanced study exists. Activities which result in significant contributions to knowledge add not only to the stature of the participants but encourage the younger men to excel in their own technical fields. Faculty seminars or their equivalent are great aids in the development of young staff members. They provide acquaintance with outside research workers, insure an influx of new ideas, and lead to industrial contacts.

The environment in which the faculty works does have a decided influence in attracting and holding graduate faculty members. Each individual faculty member is attracted to a career in education for a number of reasons, and the relative importance of a given feature depends on the specific faculty member, and on a particular institution at a given time. It is inappropriate here to indicate the relative importance of the various factors.

Broadly speaking, the conditions that influence to a large extent the over-all environment in which a faculty works might be grouped into tangible and intangible factors.

Tangible Environmental Factors

Salaries. A faculty member should have a salary commensurate with his attainments.

Faculty Benefits. Benefits, such as life insurance, hospital insurance, and retirement policies should be provided for the personal security of the faculty member and his family.

Consulting and Professional Work. Opportunity should exist for consulting and professional work with non-educational organizations. Those activities that contribute significantly to the individual's experience and growth should be encouraged. Opportunities also for additional income can be provided within university and college activities, such as extension teaching, summer teaching, short-course teaching, research, and professional services.

Institutional Financial Support. An educational institution should provide financial support so that its graduate staff members may participate in the activities of professional organizations which have no funds to underwrite personal expenses. Funds should be available to enable engineering instructors to visit industrial plants, to attend intensive short courses and symposia, and to obtain sabbatical and other leaves. These activities lead to improved teaching. Also, the effectiveness of a graduate instructor depends to a large extent on his contributions to knowledge through research and to teaching through course and program development. Funds should be available to aid the faculty member in his research activities, in new course development or revisions, and in educational research programs.

Time Allocation. The teaching load of graduate faculty members should be adjusted so that there remains time for professional and scholarly activities.

Physical Facilities. Physical environment is related to the facilities in which a faculty member has to work. Instructors should be able to work in areas where they have adequate illumination, ventilation, noise control, privacy, communications, and parking facilities.

Supporting Personnel and Services. The productivity of any individual is always enhanced by the availability of supporting personnel, such as secretarial, clerical, library, and graduate assistants, as well as mechanics, and technical and engineering assistants.

Intangible Environmental Factors

Attitudes and Policies Which Affect the Personal Life, Activities, and Satisfactions of the Faculty Member. The faculty member expects to have a clear contractual arrangement with his institution. He expects to receive equitable treatment in matters pertaining to inventions, patents and copyrights. He desires a climate conducive to publication which is free from censorship of any kind on the part of the university administration. A satisfactory provision for vacations, holidays, and absences associated with participation in professional and consulting activities is important.

The creative graduate faculty member desires the opportunity to contribute to knowledge in his field and to perfect and improve his teaching. He expects individual recognition for his achievements and an equitable evaluation of his performance.

A uniform and just policy concerning academic promotions and salary increases is an important consideration. Above all, he values a certain amount of freedom in choosing his professional and academic areas of interest and he enjoys the association with gifted graduate students and stimulating colleagues.

Policies and Environment Which Influence the Faculty Member's Performance in His University Duties. The graduate faculty member desires to participate in the administration of academic matters concerning courses, programs and graduate students. He appreciates the opportunity to advise on matters concerning the selection of new staff members who will be his colleagues. He values a certain degree of freedom in scheduling his classes and other activities. He wishes, above all, to minimize the wasting of his time in routine administrative details.

Campus Activities Which Affect the Faculty Member and His Family. A social atmosphere which is agreeable to the staff member and his family is very desirable. Well-run faculty clubs, social activities, and recreational opportunities are attractive to staff members. Cultural programs involving music, drama, and art are valued highly. Appropriate arrangements for attending student activities such as athletic contests and for use of athletic facilities such as swimming pools do much to make the university an attractive employer.

Policies and Procedures Which Affect the General Security of the Faculty Member. Academic freedom and tenure are factors which attract many creative minds to careers in universities. The continuity of employment and the feeling that one is an honored and valued staff member are extremely important to the satisfaction and general peace of mind of a teacher. The sense of satisfaction that a staff member enjoys when he feels he is an important and respected part of a university community cannot be overestimated.

(See page 974 for ASEE data on engineering degrees granted, 1925–1957.)

TABLE OF ENGINEERING DEGREES GRANTED
(A.S.E.E. data)

Academic Year	Bachelor's Degrees		Master's Degrees		Doctor's Degrees		Total Degrees
1925/26	7400	92.04%	630	7.84%	10	0.12%	8040
1935/36	8847	91.54	735	7.60	82	0.86	9664
1936/37	7881	86.94	1058	11.67	126	1.39	9065
1937/38	8245	86.85	1156	12.18	92	0.97	9493
1938/39	8697	86.86	1219	12.17	97	0.86	10013
1939/40	12408	89.69	1318	9.53	108	0.78	13834
1940/41	11358	88.11	1358	10.54	174	1.35	12890
1941/42	12709	—	n.a.	—	n.a.	—	—
1942/43	n.a.	—	637	—	84	—	—
1943/44	14145	95.78	529	3.58	94	0.64	14768
1944/45	4190	88.98	450	9.56	69	1.46	4709
1945/46	7381	87.32	988	11.69	84	0.99	8453
1946/47	18592	85.25	3090	14.17	127	0.58	21809
1947/48	27460	85.77	4303	13.44	252	0.79	32015
1948/49	41793	88.93	4783	10.18	417	0.89	46993
1949/50	48160	89.99	4865	9.09	492	0.91	53517
1950/51	37887	86.88	5134	11.77	586	1.35	43607
1951/52	27155	85.20	4132	12.96	586	1.84	31873
1952/53	21642	83.37	3726	14.35	592	2.28	25960
1953/54	19707	80.68	4130	16.91	590	2.41	24427
1954/55	20200	80.02	4444	17.60	599	2.38	25243
1955/56	23547	81.66	4678	16.22	610	2.11	28835
1956/57	27748	82.71	5203	15.51	596	1.78	33676

NSF SPONSORS REFRESHER STUDY FOR HIGH SCHOOL TEACHERS

Approximately 800 high school teachers of science and mathematics are currently enrolled in concentrated courses of study sponsored by the National Science Foundation. The courses, conducted for the regular academic year, are specially designed to bring secondary teachers up to date in the various fields of mathematics and science. The program was developed by the Foundation in response to Congressional request that steps be taken to improve the teaching of these subjects at the high school level.

Sixteen universities and colleges are offering the Foundation-sponsored courses. Approximately $4,500,000 has been made available to these schools in the form of grants to provide stipends of $3,000 plus travel expense and $300 per dependent to the participating teachers. Participants were chosen on the basis of ability and aptitude from among teachers with three or more years experience in the teaching of mathematics and science subjects.

Participating schools are the Universities of Chicago, Colorado, Illinois, Michigan, North Carolina, Texas, Utah, Virginia, and Wisconsin; Harvard University, Ohio State College, Oklahoma, Oregon and Pennsylvania State Colleges, Stanford University, and Washington University at St. Louis.

EDUCATION ADVISORY COMMITTEE NAMED BY MANUFACTURING CHEMISTS' ASSOCIATION

In an expansion of its education cooperation activities, the Manufacturing Chemists' Association announced the appointment of a new Education Advisory Committee. In pointing up its importance, General J. E. Hull, U.S.A., (Ret.), MCA president, commented: "While education cooperation activities have been a formal part of the MCA program for a number of years, the new committee, composed of senior chemical industry executives and specialists in education or public relations, reflects the growing importance of close liaison between industry and higher education."

The new committee will under the chairmanship of Bromwell Ault, vice president, Interchemical Corporation (New York). Glen Perry, assistant public relations director, The Du Pont Company (Wilmington, Deleware), was named vice chairman. The committee includes three chemical company presidents and four vice presidents. The MCA staff secretary to the committee is Dr. William E. Chace, director of education.

The chemical industry now employes 62,700 scientists and engineers—about one out of twelve of total chemical employment. Defining the aims and purposes of the new committee, Mr. Ault said:

"The chemical industry, as the largest employer of engineers and scientists, is seriously concerned about the present shortage of scientists and other technically trained personnel.

"The purpose of this committee is to review the existing industry education program and decide how it can best be expanded. Our primary goal is to interest more young men and women in careers in science."

MCA Education Advisory Committee

Bromwell Ault, vice president, Interchemical Corporation (New York) (chairman)

Glen Perry, assistant public relations director, E. I. du Pont de Nemours & Co., Inc. (Wilmington, Del.) (vice chairman)

W. Austin Bishop, public relations director, Pennsylvania Salt Manufacturing Co. (Philadelphia, Pa.)

Emery N. Cleaves, vice president, Celanese Corporation of America (New York, N. Y.)

Paul L. Davies, president, Food Machinery and Chemical Corporation (San Jose, California)

T. C. Fetherston, assistant public relations director, Union Carbide and Carbon Corporation (New York, N. Y.)

R. B. Fiske, vice president, American Cyanamid Company (New York, N. Y.)

Julian W. Hill, executive secretary, Committee on Fellowships and Grants, E. I. du Pont de Nemours & Co., Inc. (Wilmington, Del.)

John R. Hoover, president, B. F. Goodrich Chemical Company (Cleveland, Ohio)

Thomas Kennedy, industrial and public relations director, Atlas Powder Company (Wilmington, Del.)
James G. Park, vice president, Enjay Company, Inc. (New York, N. Y.)
Arthur Smith, Jr., public relations director, The Dow Chemical Company (Midland, Michigan)
S. L. Stark, technical employment and salary administration, The Dow Chemical Company (Midland, Michigan)
Arthur V. Wilker, trustee, The Union Carbide Educational Fund, Union Carbide and Carbon Corporation (New York, N. Y.)
J. Albert Woods, president, Commercial Solvents Corporation (New York, N. Y.)

ASEE SUMMER SCHOOL ON PRINCIPLES OF LEARNING

A summer school on principles of learning in engineering education will be held on Friday and Saturday, June 20–21, the week of the ASEE Annual Meeting, at the Berkeley campus of the University of California.

The summer school will assemble teachers and psychologists to explore methods for learning consistent with psychological principles and objectives of professional education. Interchange of ideas and experiences will emphasize operational features of the teaching-learning function and will not retrace frequently explored areas of curricular and informational content of education for engineering.

Dormitory rooms and meals will be available on the same basis as for the Annual Meeting. Summer school facilities have been planned for 100 participants and additional registration can be accepted only to the extent of available facilities. A preference will be given to young engineering teachers among early registrants. The registration fee of $3 should be mailed with the letter of application to Professor James S. Campbell, Department of Industrial Engineering, University of California, Berkeley 4.

This program is jointly sponsored by the Educational Methods Division and the Committee for Young Engineering Teachers.

DEANS' CONFERENCE PROCEEDINGS

The United State Atomic Energy Commission has recently issued a 200-page proceedings volume from the Deans' Conference on engineering education and nuclear energy, held September 5 to 8, 1956, in Gatlinburg, Tennessee. Arranged by the AEC, the Oak Ridge Institute of Nuclear Studies, the Oak Ridge National Laboratory, and the ASEE, the Conference included papers by leading educators, industrial administrators, and government officials, including AEC commissioner W. F. Libby. The proceedings include transcripts of the papers by the twenty-nine speakers, and a list of conference participants.

Dr. W. W. Grigorieff, chairman of the University Relations Division of the Oak Ridge Institute of Nuclear Studies, is editor of the report TID-7527. It is now available at a cost of $1.00, from the Office of Technical Services, Department of Commerce, Washington 25, D. C.

JAPANESE SOCIETY FOR ENGINEERING EDUCATION

NAGOYA INSTITUTE OF TECHNOLOGY
GOKISO-CHO SHOW A-KU
NAGOYA, JAPAN

President W. L. Everitt
The American Society for Engineering Education,
University of Illinois, Urbana, U.S.A.

Dear President Everitt:

It is a great honor and extreme delight that we had your cordial message on the occasion of the Fifth Annual Meeting of our Japanese Society for Engineering Education. As you know, the impetus of establishment of our society was the visit of the American Advisory Mission to Japan for Engineering Education in the Summer of 1951. It is, therefore, especially significant and delightful for us to have invited Dr. H. L. Hazen, who was Chairman of the Advisory Mission, as our honorable guest and also as the representative of your society.

Our society has tried our best for five years to develop activities for engineering education, modeling after your venerable society 60 years older than ours. It is still young, but we are happy to know that it is effecting good results over our engineering education. It is also our pride that our two societies are unique as national societies in the world, as you say in your message.

It is generally recognized that an educational plan is easy to form, but very slow to produce any substantial result. This is one of the difficulties we face in executing our actities. Another diffi-

culty is that university professors prefer research to teaching in Japan. In spite of these and other difficulties, we want to continue our effort as your society has made for the promotion of the industry of your country for so many years, because we firmly believe our society will have great influence over the development and prosperity of our industry. We may be discouraged, however, in some difficult occasion, when we need your help and encouragement.

Dr. Harold L. Hazen, your representative, gave us not only his congratulation on our anniversary, but very useful speeches at our meeting and meetings in several regional societies, which impressed us very deeply.

We wish to express our hearty gratitude for your cordial message and sending Dr. Hazen as your representative.

With very best wishes,
Sincerely yours,

S/Kinji Shimizu
Kinji Shimizu
President,
Japanese Society for
Engineering Education

PUBLICATIONS RECEIVED

A Directory of Independent Commercial Laboratories Performing Research and Development, 1957, released in March by the National Science Foundation, lists 565 laboratories together with names of senior officers, numbers of research staffs and types of research activities. Copies can be purchased from the Government Printing Office.

Pre-College Science Center, the story of an experiment in the field of science education, has recently been published by the Dorr Foundation in Cooperation with the Loomis Institute. The booklet describes a new way in which a philanthropic foundation, thirteen industries, and a secondary school teamed up to use their resources toward developing scientific interests and abilities in talented high school boys.

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